INDEX TO SCIENCE CONSPECTUS, VOL. IV

SCIENCE CONSPECTUS

VOL. IV — 1914 — No. 1

THE AERONAUTICAL ENGINEER

DEVELOPMENT OF THE MODERN AIRSHIP DUE TO ENGINEERING RESEARCH WHICH IS NOW BEING CARRIED ON VIGOROUSLY IN GREAT BRITAIN AND ON THE CONTINENT

BY JEROME C. HUNSAKER

THE early history of aircraft is essentially a record of the contributions to knowledge of scientists and engineers, interspersed at intervals with the records of performances of daring aëronauts who were more in the public eye. For example, the development of the modern airship began with the discovery of hydrogen by the chemist Cavendish in 1766. In 1768 Cavallo, the physicist, showed hydrogen soap bubbles to the Royal Society. In 1783 Professor Charles of Paris constructed and made a flight in the first hydrogen balloon.

The dirigible balloon or modern airship was developed by the engineers Giffard, General Meusnier, Tissandier, Captain Renard, and the naval architect Depuy de Lôme. Their efforts were not crowned with success because at that time the gasolene motor had not been perfected. The modern airship is the direct product of the application of the gasolene motor to the early dirigibles. The non-rigid type was perfected in France by the engineers Santos Dumont, Lebaudy, and Surcouf; and in Germany by Major Gross, Major von Parseval, and the engineers Basenach and Reidinger. At the same time the rigid type, conceived by Schwartz, was successfully developed by Count Zeppelin. All these are men of superior engineering training.

Similarly the aëroplane can be traced from the experiments of Sir George Caley who in 1810 analyzed the mechanics of flight and conducted experiments with gliders. The development of the modern aëroplane can be outlined by means of the following table:

1866	Wenham	First monoplane glider.
1868	Stringfellow	Steam driven model aëroplane.
1879	Tatin	Compressed air driven model aëroplane.
1891	Hargrave	Box kite, with remarkable stability.
1893	Phillips	First wind tunnel research.
1895	Lilienthal	Long distance gliding.
1896	Langley	Gasolene driven model aëroplane.

These men were all engineers, and each one contributed something of value to our knowledge of dynamic flight. The application of the principles they had discovered and enunciated resulted in the invention of the first aëroplane. As in the case of the dirigible balloon, the efforts of the pioneers were unsuccessful until the introduction of the gasolene motor. The pioneers whose work was most valuable were, to name a few of them, Maxim, Ader, Chanute, Ferber—all men of engineering training. The Wright brothers, to whom we owe the first practical aëroplane, had the assistance of Mr. Chanute and Mr. Huffaker,

who had been Professor Langley's assistant.

At the present time our knowledge of aëronautics is being broadened by the scientific research of many men in the universities and testing laboratories of Europe.

Considering the importance to the art of the trained engineer, it is only a step farther to the time when this art will have developed into an industry which will demand engineers especially trained to handle its problems. At the present time such engineers as are employed on aëronautical work are in a sense self-taught. They were first engineers, and in time came to be qualified as aëronautical engineers. With the growth of an aëronautical industry abroad has recently come a demand for technically trained men, aëronautical engineers, and the technical schools are beginning to supply this demand.

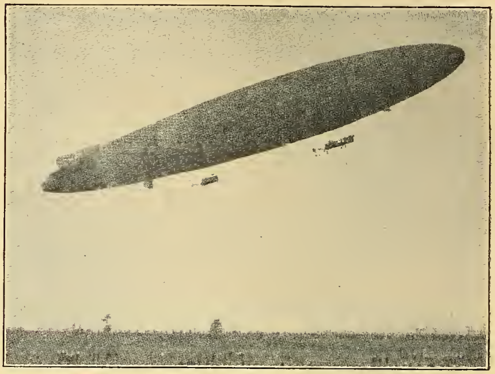
However, before considering what steps are being taken in this direction, it may be well to consider the status of aëronautics at the present time.

Commercially, the airship as developed in France and Germany has met with small success on account of the high cost of operation, frequency of accident, and small carrying capacity. It is true that certain passenger ventures have seemed to prosper, but they have been subsidized by the state or a society interested in educating the public. In no way has the airship been used as a transportation facility for commercial purposes.

The aëroplane in the days of a fascinated public in Europe, as here at home, offered a great attraction for the showman, and exhibitions and races were largely attended. Large prizes were offered by enthusiastic men. Now the public has had its opportunity to see the flying machine and it inquires, "Of what use is it?" Commercially, due to unreliability, small carrying power, and expense, the aëroplane has found no application except a recent attempt to carry the mails across the Sahara desert.

From the point of view of the sportsman, the airship is too costly and the aëroplane too dangerous to have a large following. There is a chance, however, that the flying boat recently brought out by Curtiss in America may appeal to sportsmen.

The naval and military interest in aircraft contrasts strongly with the scepticism of the general public. It can fairly be said that the rapid development of all types of aircraft in the past few years has been due almost wholly to the moral and financial encouragement of the great military powers of Europe. We in America are not a great military power and we have no vital interest in developing aircraft so long as our possible enemies lie beyond the probable radius of action of such craft. It is for this reason, no doubt, that progress in aëronautics during the past five years has been almost entirely due to the enterprise of foreigners.



The Schüette-Lanz, German dirigible with rigid frame of wood

Nevertheless, we now have vulnerable outposts at Panama and the Philippines, and there is already an awakening interest in military aëronautics due to the Mexican problem.

At the present time, from consideration of the same problem of national defense, England, Germany, France, Russia, Italy, and Austria have decided to maintain aircraft for war use. It is hardly possible that these governments should be united in a common mistake in policy.

It appears to be the general opinion

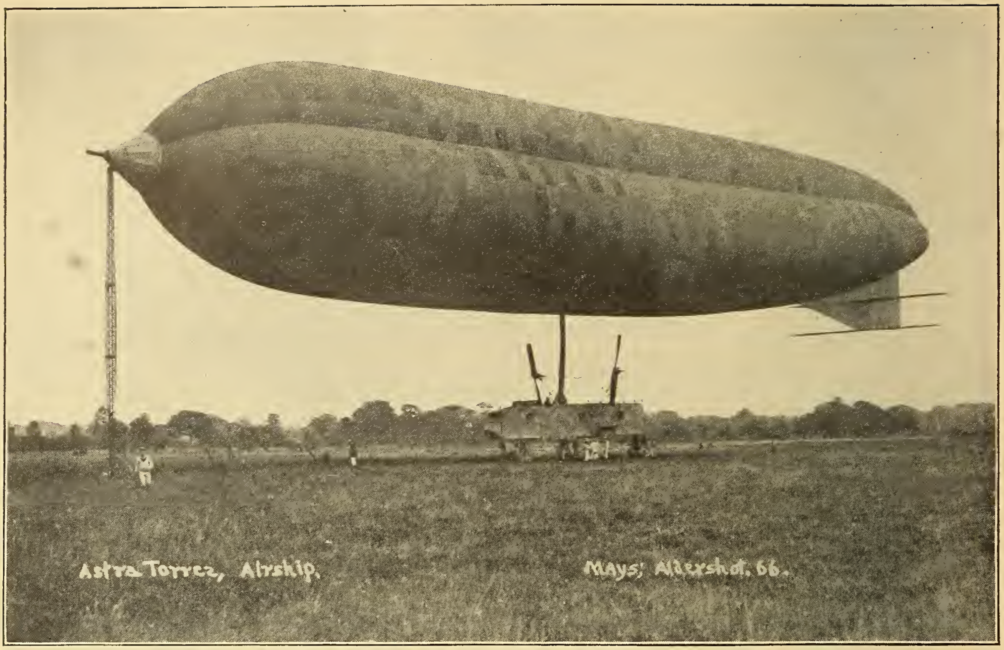
Schwaben, German Zeppelin which carried over 4,000 passengers in four months

that the aëroplane is suited for scouting operations in which the flight out and return can be made in daylight and within a radius of 150 to 200 miles. It is necessary for the aëroplane to return to its base to report its observations in the present stage of wireless telegraphy. The Italian experience with aëroplanes during the recent war with Tripoli led to the conclusion that an aëroplane must operate at an altitude of at least 3,000 feet in order to be safe from rifle fire. At such an altitude the high speed of the aëroplane offers little hindrance to careful observation of the ground, and it is possible to distinguish bodies of troops, their direction of march, presence or absence of bridges, condition of railroad tracks, and the general arrangment of camps. It is not possible to distinguish troops which are deployed or which are marching through wooded country.

It has been urged that aëroplanes may be used offensively to drop bombs upon hostile troops, but due to the fact that an aëroplane can operate only in daylight and at an altitude greater than 3,000 feet, the chance of making a hit with a bomb dropped from such a height is very small. At the same time, the radius of action of an aëroplane is so small that it seems unwise to sacrifice weight devoted to fuel storage to a supply of bombs. Furthermore, the small bombs that can be carried by an aëroplane are not likely to have a very destructive effect.

The use of the machine gun from an aëroplane will probably be of service against the enemy's dirigible balloons, and it seems to be the general opinion that the offensive use of aëroplanes will be confined to action against the enemy's aircraft.

The hydro-aëroplane and flying boat appear to be well adapted for scouting over inland and coastal waters, and the recent development of the flying boat renders it suitable for scouting at sea in



Astra-Torres, non-rigid dirigible (French), moored to a mast at British Army Aviation Field, Aldershot

conjunction with the fleet. The flying boat may be carried aboard a battleship and launched from a catapult or from the water alongside. It can be expected to conduct scouting operations over a radius of 100 miles from the ship, and in ordinary weather may land on the lee side of the ship and be hoisted aboard. At the present time the principal defect of the flying boat is its limited radius of action due to the weight that must be sacrificed for the hull. Furthermore, the flying boat is unable to land upon a rough sea, so that the days it may be used are limited by weather conditions.

For both land and ocean scouting, it has been found necessary to carry an observer in addition to the pilot. It is not considered satisfactory to require the pilot to do more than operate his machine. In aëroplanes which are expected to make long trips the controls are duplicated in such a manner that the pilot and the observer may relieve one another.

The airship in time of war or immediately preceding the outbreak of war will probably be used for long distance strategical reconnaissance, for which service the aëroplane is not satisfactory. For instance, the radius of action of the non-rigid airship may be made as high as 1,000 miles. The airship can travel at night and can be fitted with a wireless telegraph both for sending and receiving messages. If the speed of such a dirigible be above 45 miles per hour, it can probably be operated 85 days out of 100 in central Europe. The large non-rigid dirigibles may have a radius from 1,500 to 2,000 miles and have a correspondingly greater value for long distance scouting, but at the same time require extensive sheds for housing. On the other hand, the non-rigid ships may be moored by the nose to a mast in an open field in good weather, and in case of storm the non-rigid envelope may be deflated and so save the ship from destruction. The non-rigid ship can be transported by automobile trucks or by railroad and inflated in the field from a portable gas generator.

For naval purposes the non-rigid airship seems well adapted for operations

Dunne Biplane (England), designed for inherent stability

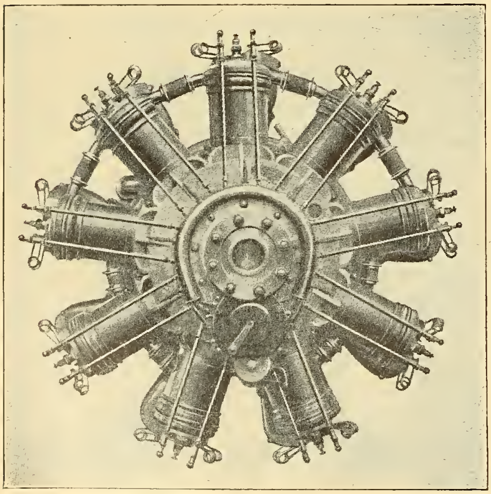
over seas. The dirigible may be carried aboard a transport or supply ship to the advance base that has been seized by the fleet and sent out to determine the location and strength of the enemy's fleet.

The dirigible both of the rigid and non-rigid types may play a part in offensive operations in time of war, but it is hardly likely that a commander would risk having one of his dirigibles destroyed in an attempt to drop bombs upon an enemy's position. The dirigible presents such a large target that by day it is considered necessary to remain at an altitude of at least 5,000 feet to be safe from gun fire. From such a height bomb dropping would be very difficult. However, at night when the dirigible's movements are hidden such a ship might well pass low over an enemy's camp, dock yard, arsenal or magazine and by dropping high explosives or incendiary bombs effect considerable damage. A modern dirigible can be provided with ten 100-pound torpedoes filled with high explosive. For offensive operations against armored vessels it is not likely that the surface explosion produced by such a torpedo striking a deck or turret top would produce any serious damage. However, the moral effect of dropping bombs at night into an enemy's camp or fortress is difficult to estimate.

The tactical uses of aircraft in war cannot be discussed fully here. The experience that European nations gain from their manœuvres is kept profoundly secret. On the other hand the conclusions that such nations reach as to the value of aircraft are made apparent by their increased activity in building them. For example, the past summer naval manœuvres of the British fleet in the North Sea have been followed by great activity on the part of the Admiralty in purchasing French, German, and Italian dirigibles and in large orders to British aëroplane builders. The reasons

Nieuport Monoplane fitted with hydroplane floats

upon which this decision to establish an aërial fleet has been reached are unknown to us, but they must have been sufficient.



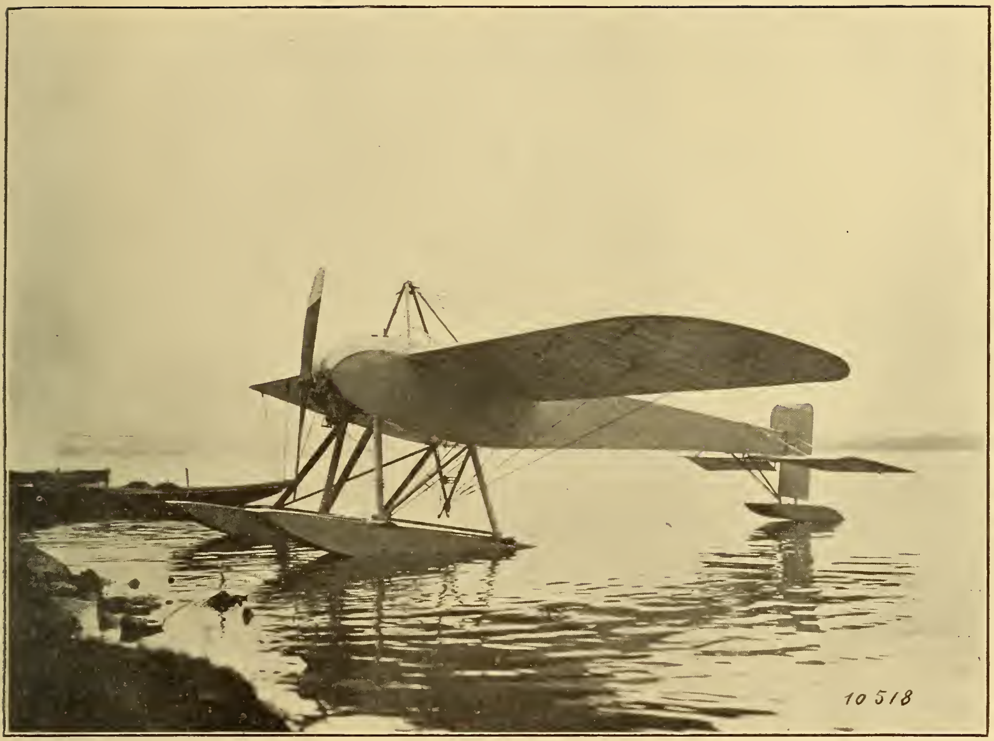
Salmson (Canton-Unné), 125 h. p., water-cooled, 9 cylinders, fixed

The building of aircraft is a recognized industry in France, Germany and England. The French army intends to have 1,000 aëroplanes in service as soon as a sufficient number of men can be trained as pilots. The Farman factory alone is turning out one complete aëroplane a day. In England the Royal Aircraft Factory employs 750 men working on experimental machines exclusively. In Germany one airship factory expects to turn out five ships in the coming year.

With all this activity it is natural to ask who is directing it. In nearly every case it is the engineer who is qualified in aëronautics.

The growth of the aircraft industry in the United States can be forced by the policy of the government or it can be the natural result of a radical improvement in the machines tending to make them more trustworthy.

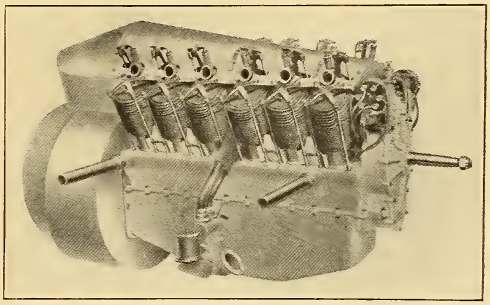
A part of the great sums of money spent for military aëronautics abroad has found its way into experimental and engineer-



Borel Monoplane, showing wing stays of wire cable running to upper and lower king posts

ing research with most satisfactory results. Flying is today safer than a year ago, and infinitely safer than four years ago. In the earlier days of the art, structural failures were frequent, but from a better understanding of the forces involved an engineer can now provide an adequate factor of safety in his design. The stability of aëroplanes is better understood, and though the non-capsizable aëroplane has not yet been produced it is reasonable to suppose that the future will bring new light on this subject. Aëroplane surfaces are more efficient, and motors more powerful and more reliable. The speed of 40 miles an hour reached by the first Wright aëroplane has been increased to over 120 miles an hour in the Deperdussin monoplane of 1913. At the same time the radius of action of the earlier aëroplanes of about 50 miles has been increased to 700 miles in the modern French single seater monoplane. Similar improvements in speed and radius of action have been effected in dirigibles until we have the modern French and German dirigibles capable of a speed in excess of 50 miles an hour.

At the present time the most successful aëronautical research is being prosecuted in England at the National Physical Laboratory on small models and



Renault, 90 h. p., water-cooled, 12 cylinders

Albatross Monoplane

at the Royal Aircraft Factory on full sized machines. These two institutions are directed and their efforts coördinated by a committee of eminent scientists and engineers, headed by the physicist Lord Rayleigh. The results of their experiments have produced the famous military biplane known as B E 2, in which a speed in the air of 80 miles an hour is combined with a speed in landing and starting below 37 miles an hour. Its stability is excellent, and its construction is rugged and at the same time light and elastic.

At Northampton Institute in London courses are given in aëronautical engineering, and a wind tunnel is installed for the instruction of students.

In France the foremost civil engineer, M. Gustav Eiffel, has retired from the practice of his profession and is devoting the remainder of his life to aëronautical research. His private laboratory has the most powerful wind tunnel in the world with an 80-mile-an-hour blast of wind. Inventions and new designs are tested by him without fee on the sole condition that the results shall be published for the benefit of the aëronautical industry of France.

The French army maintains an experimental laboratory at Chalais-Meudon, and the University of Paris has an extensive "aëro-technic" laboratory at St. Cyr, including a whirling arm and wind tunnel for model work and a dynamometer car electrically propelled on a track upon which full sized aëroplanes or propellers may be mounted for study.

The "École Superieure Aëronautique" has been founded to educate aëronautical engineers. A one-year course of a post-graduate character is given by a faculty including some of the most able men of the Polytechnique. Only graduates of a first grade engineering school are admitted. Forty men completed the the course in 1912–1913.

In Germany, the University of Göttingen has a well-equipped aëronautical laboratory conducted by Doctor Prandtl, the head of the department of mechanics. Candidates for the degree of doctor of

philosophy are admitted as research assistants.

The technical high schools of Berlin and Aachen have provided aëronautical laboratories and offer courses in aëronautical engineering to students who have completed the required courses in mathematics and mechanics.

It is apparent that the future of aëronautics depends upon the results of research work. The elements of flight have been discovered and it is now a problem of perfecting the first crude machines. It is the history of human achievement that such perfection has always been

Ten Blériot Military Monoplanes dismounted for shipment to a French frontier post

brought about. From a military point of view there appears to be a race for supremacy in the air by the great European powers. The race cannot be won by the mere multiplication of existing types because the production by one country of a type of aircraft of marked superiority to any now existing will immediately render obsolete the entire aërial fleets of her rivals. The race, therefore, is not only between factories and constructors, but also between the designers and the staffs of the research laboratories.

OUR EUROPEAN POPULATION

In the *Journal* of the Washington Academy of Sciences for January 4, 1914, occurs a brief résumé of an interesting talk by Dr. Daniel Folkmar before the Anthropological Society of Washington on "Some Results of the First Census of European Races in the United States." If the total white population of the United States in 1910, about 82 millions, be taken as 100 per cent., the native stock constitutes 60.5 per cent. The "foreign stock" made up thus 39.5 per cent. of our white population in 1910. Of this, 27.1 per cent. came from northwestern Europe, *i. e.*, English, Germans, Scandinavians and North French while less than 13 per cent. came from southern and eastern Europe, mostly Poles, Yiddish Hebrews, Italians, Greeks and Bulgarians. The five linguistic races contributing most are, in order, English, German, Italian, Polish, Yiddish; the English furnishing about 10 millions, the German 7 millions and none of the others equalling one quarter of the German.

H. W. S.

VOLCANIC ERUPTIONS AFFECT CLIMATE

Dr. C. G. Abbott, director of the Astrophysical Observatory of the Smithsonian Institution, advances the theory that volcanic explosions affect the climate directly. It is certain that an agency capable of sending great clouds of dust twenty miles high in the air, to be distributed by the winds all over the world, and to remain in suspension for months, causing the decrease of the direct radiation of the sun by as much as 20 per cent., is a climatic influence not to be ignored.

While making measurements of the quantity of heat coming from the sun at Algeria two years ago, Dr. Abbott noted streaks resembling smoke lying along the horizon, which, in the course of a day or so, developed into such a haze that work was practically impossible. This condition lasted for nearly three months.

SUGAR AS AN ANTISEPTIC

Sugar as a surgical antiseptic has been recommended by an eminent German surgeon; although all saccharine substances are good, pure cane or beet sugar is best. It is said that it is not injurious to the blood, and is a better preventive of putrefaction and contamination by microbes than ordinary medical antiseptics.

THE VITAMINES

THE RECOGNITION OF ESSENTIAL CONSTITUENTS OF THE DIET HITHERTO UNCLASSIFIED — DEFICIENCY DISEASES

BY PERCY G. STILES

If a physiologist is asked what are the requisites of a normal diet he will probably reply somewhat as follows: First, it must represent an adequate quantity of available potential energy, not less than 2,000 calories for the average human adult. Second, it must contain protein (nitrogenous) food sufficient to compensate for the unavoidable daily loss of similar material from the body. Third, it must be palatable and digestible, making due allowance for personal idiosyncrasy. He will very probably content himself with these three postulates.

If the inquiry is pressed the man of science may recollect that another necessary condition of successful nutrition is a proper supply of the inorganic or mineral elements in sufficiently varied assortment. The tissues cannot be developed or maintained without chlorides, phosphates, and other saline contributions. The need for substances of this class is more urgent during the period of growth than later but it always continues to exist. A similar statement may be made with reference to the protein of the ration; this, too, must be furnished in relative abundance and varied form during the growth of the subject and may be reduced when full stature has been reached. Mendel has shown that kind as well as quantity must be considered when protein is chosen for experimental nutrition of an animal. Proteins from certain sources suffice for maintenance only and not to minister to growth.

With the accumulation of physiological data during the past few years it has become increasingly apparent that there may be criteria for the adequacy of a diet not included in the list just given. There are now known to be organic compounds other than proteins, small quantities of which are absolutely essential to normal growth and even to continued health in the adult condition. The name of Vitamines has been proposed for all such substances. The word is well chosen in view of its root-meaning; an amine is a nitrogenous compound of a certain type and a vitamine is obviously such a compound with the added distinction of being necessary to life. Casimir Funk of London has been one of the foremost contributors to the development of this conception and a valuable summary of his own work and his judgment of the work of others may be found in the *Ergebnisse der Physiologie*, Vol. XIII, pp. 124–205. (Wiesbaden, 1913.) This article is the chief source of the present abstract.

A class of serious disorders has long been known in which failure of nutrition could be named as the cardinal fact in the case and in which it has somewhat vaguely been assumed that the diet must be at fault. The most familiar disturbance of this class, at least to the general reader, has probably been scurvy. The chronicles of exploring expeditions in polar regions have contained many harrowing accounts of the ravages of this disease. It has usually been associated with the consumption of a monotonous ration, deficient in fresh vegetables and often containing a great deal of salted or canned food. Certain supplementary articles of diet, such as onions, limes, and lemons, have been credited with some power to ward off or at least to mitigate the trouble and they have been spoken of as antiscorbutics.

The victims of scurvy suffer from severe prostration, loosening of the teeth, intense

soreness of the gums, friability of the bones, and a tendency to hæmorrhage partly due to a loss of the coagulating property of the blood. Those who have read the classic journals of Doctor Kane will recall the distressing situation on board his ship at the end of the Arctic winter and the commander's device to cheer his helpless men in the forecastle by setting up a mirror to bring into their midst the first sunbeam from the southern horizon. Scurvy has become less common with better supplies of food available for such parties but it has been noted within a very few years.

Another disorder which has lately attracted much attention is beri-beri, It has its recognized centre in the East, particularly in Japan, China, Indo-China, and the Philippines. Its occurrence in Newfoundland has recently been reported. Those who suffer from beri-beri are usually the very poor and, in the Orient at least, they are people who live chiefly upon rice. In Japan the disease has been nearly eliminated from the army and navy by providing more liberal and varied rations. The symptoms are complex but they are in general such as can be referred to the impairment of the nerves which is known to be the most prominent physical change. There is a period of declining weight and strength and this is followed by the development of a "multiple neuritis" with partial paralysis in both the motor and the sensory realms.

Various theories have been held with regard to beri-beri. It has been believed to be an infectious disease because it so often affects a large number of people who are closely associated, as in a prison, a ship, or a laborers' camp. The fact was formerly overlooked that such companies share the same diet and that their trouble may well be due to that source. This is now accepted as proved. But when the decision is reached that something must be wrong with the food there are still two possible views to be considered. Is the diet positively poisonous or is it merely insufficient? This question has been asked both with reference to scurvy and to beri-beri. It is not easy to answer it in such a way as to meet all objections. Nevertheless, the tendency is toward the conclusion that it is the inadequacy rather than the toxic nature of the food which is to be held responsible in these and perhaps in other cases.

It is proposed to call such failures of nutrition "deficiency diseases." It is assumed that the lack is of one or more of the specific substances already termed vitamines. The evidence in support of such a conception is especially convincing in the case of beri-beri. As long ago as 1897 it was discovered that rice which has been "polished"—that is, deprived of its pericarp or immediate husk—has a tendency to induce beri-beri and that the inclusion of the pericarp makes it entirely wholesome. It has been possible to confirm this in a striking manner by experiments on birds. If a fowl or a pigeon is restricted to polished rice as a diet it soon refuses to eat. If forced feeding is then resorted to it soon becomes pitiably weak and cannot long survive. The partial feeding is thus as surely destructive as absolute starvation. Post-mortem study of such birds shows marked degeneration of the nerves. The service of the pericarp may be conceived of in either of two ways. The polished rice may contain an active poison for which the husk provides a natural antidote. The alternative is that the pericarp furnishes a necessary constituent of the nerve tissue, a vitamine, for want of which the nerve-fibres deteriorate. How hard it is to choose between these two views has already been suggested.

Funk has been successful in his patient endeavor to isolate the vitamine the lack of which causes beri-beri. He has obtained from the pericarp of rice a number of fractions, only one of which has the remedial property. This appears to be a definite organic body to which a formula can be assigned. It contains nitrogen but not phosphorus, an element which earlier workers had believed to be concerned. The vitamine can be separated from other foods than rice. Various animal tissues yield it and so do certain vegetables. Any kind of food which contains the vitamine may be

used to supplement a ration of polished rice with the result that it becomes sufficient for the maintenance of the animal. Yolk of egg and yeast are said to have the curative power in the highest degree.

It is interesting to follow Funk's conjectures as to the systemic effects of the withholding of the invaluable vitamine. We know that in starvation the organs which cannot be spared are sustained at the expense of others. The heart and the nervous system have been found to keep their full weight to the last while tissues which are less necessary to the continuance of life are greatly reduced. Even the bones are levied upon to the extent of one sixth of their mass. We may expect to see the same principle illustrated in the partial starvation which is at the root of any deficiency disease.

So in beri-beri it may be supposed that the vitamine which is absolutely essential to the normal nervous system is not at first confined to that part of the body. The feeding experiments have given evidence that it is present in the muscles though rather scantily. It is to be expected that in the event of failure of a supply direct from the diet the muscles will be made to surrender their store of the vitamine to replace that which has been destroyed in the nervous tissues. If we are to think that the vitamine is essential to the muscles as well as to the nerves we shall anticipate that its withdrawal will result in a disintegration of the muscle protoplasm quite out of proportion to the small amount of vitamine yielded to the preferred creditor. So for a while there will be loss of weight and strength but no marked nervous symptoms because the nerves are being kept in condition at the cost of a remorseless sacrifice of the other tissues. When the internal supply ceases to be sufficient the acute nervous effects are at once developed.

It is the opinion of Funk that both beri-beri and scurvy are prevented by the liberal use of potatoes. Before this vegetable was introduced into Europe there were severe epidemics which are believed to have been outbreaks of scurvy. The suggestion that the potato should now be added to the food-supply of the eastern countries in which beri-beri is prevalent seems a wise one. But the fact is to be emphasized that almost any diet is free from objection if it is reasonably varied. It is where poverty or some other compulsion is operative that nutritional disasters are likely.

The condition of the body in scurvy is quite different from that in beri-beri and the missing compounds are probably somewhat unlike. Some articles of diet may protect against both; some may be specific for only one. Allied with scurvy are the disorders called ship beri-beri, infantile scurvy (Barlow's disease), and the experimental scurvies which can be produced in animals by limiting the intake to a few foods. Still other pathological states may be found to have a more or less similar basis. An attempt has been made to justify the claim that pellagra is a deficiency disease but this is strongly contested. Abnormalities of early development such as rachitis (rickets) and, perhaps, later perversions of growth such as cancer may be connected with the lack of certain chemical constituents in the income of the body. At this point it may be in order to say that the diet itself may conceivably be ideal and yet there may be a failure to utilize the vitamines offered either because of a failure to absorb them or because of their premature decomposition in the alimentary tract.

A few years ago Crichton-Browne, an English authority, in passing an unfavorable judgment upon the dietetic standards of Chittenden and others called attention to the fact that the diet approved by them seemed to correspond closely with that of the very poor. The comparison was based upon fuel value and protein content. It is now possible to modify the statement that the two are precisely equivalent. The low diet of the New Haven school is an inclusive one while that of the poor is of limited variety. A supply of the requisite minor bodies—vitamines, if we adopt the term—is much more surely to be relied on in the first case.

Bunge, the Austrian physiologist,

pointed out in 1901 that sugar is an unnatural food, in that it has been refined to the exclusion of all compounds but saccharose. Foods which are not deliberately prepared by industrial or domestic processes are always mixtures, however much one constituent may predominate. The teaching of Sylvester Graham in the first half of the nineteenth century that the foods offered by nature should not be separated into their ingredients but taken in their entirety is frequently reëchoed in our own day. In the light of studies like those of Funk it is apparent that there is a certain foundation for the idea that foods may be "denatured" either by discarding valuable fractions or by modes of preparation which destroy essential compounds. The fear that disturbances of nutrition from such causes threaten the American people as a whole may be dismissed, but it is interesting to have a new insight into a matter which under certain conditions becomes of pressing importance.

MAN'S PEDIGREE

In his paper on The Evolution of Man Prof. G. Elliot Smith says:—

No one who is familiar with the anatomy of man and the apes can refuse to admit that no hypothesis other than that of close kinship affords a reasonable or creditable explanation of the extraordinarily exact identity of structure that obtains in most parts of the bodies of man and the gorilla. To deny the validity of this evidence of near kinship is tantamount to a confession of the utter uselessness of the facts of comparative anatomy as indications of genetic relationships, and a reversion to the obscurantism of the dark ages of biology. But if anyone still harbors an honest doubt in the face of this overwhelming testimony from mere structure, the reactions of the blood will confirm the teaching of anatomy; and the susceptibility of the anthropoid apes to the infection of human diseases, from which other apes and mammals in general are immune, should complete and clinch the proof for all who are willing to be convinced.

Nor can anyone who, with an open mind, applies similar tests to the gibbon refuse to admit that it is a true, if very primitive, anthropoid ape, nearly related to the common ancestor of man, the gorilla, and the chimpanzee. Moreover its structure reveals indubitable evidence of its derivation from some primitive Old World or catarrhine monkey akin to the ancestor of the langur, the sacred monkey of India. It is equally certain that the catarrhine apes were derived from some primitive platyrrhine ape; the other, less modified descendants of which we recognize in the South American monkeys of the present day; and that the common ancestor of all these primates was a lemuroid nearly akin to the curious little spectral tarsier which still hunts the forests of Borneo, Java, and the neighboring islands, and awakens in the minds of the peoples of those lands a superstitious dread—a sort of instinctive horror of the sight of the ghost-like representative of their first primate ancestor.

This much of man's pedigree will I think be admitted by the great majority of zoologists who are familiar with the facts; but I believe we can push the line of ancestry still further back, beyond the most primitive primate into Haeckel's suborder Menotyphla, which most zoologists regard as constituting two families of insectivora. I need not stop to give the evidence for this opinion, for most of the data and arguments in support of it have recently been summarized most excellently by Dr. W. K. Gregory.

BY WIRELESS 6000 MILES

Communication was recently held between the wireless station at Nauen, Ger., and one at Windhoek, Cape of Good Hope, South Africa. The messages that passed were clear and distinct. The distance between Nauen and Windhoek is approximately six thousand miles. At various times there have been reports or messages traveling six thousand miles of more, but very few, if any, of these have been direct communications.

THE QUEEN CHARLOTTE ISLANDS.[1]

DESCRIPTION OF THESE LITTLE-KNOWN ISLANDS AND OF THE ORIGINAL INHABITANTS, THE HAIDA INDIANS—EVENTFUL GEOLOGIC CAREER OF THE GROUP

BY J. D. MACKENZIE

INTRODUCTION

The Queen Charlotte Islands, comprising one of the remote districts of Canada, are an interesting and little-known group. During the past summer the writer spent three months on these islands, with a party engaged in field work for the Geological Survey of Canada, and some of the results of our investigations are here set forth.

The Queen Charlotte Group, stretching from 52° to 54° 15′ north latitude, and from 131° to 133° west longitude is situated in the North Pacific Ocean, 140 miles north of Vancouver Island, and about 40 miles south of the southern extremity of Alaska. The islands form a slightly curved triangle, shaped like the truncated end of a crescent convex toward the Pacific, with its apex pointing south. The length of the triangle in a northwesterly direction is about 190 miles, and the width of its base, the northern coast of Graham Island, is 60 miles.

The Grand Trunk Pacific Steamship Company maintains a regular passenger and freight service between Victoria, Vancouver, Prince Rupert, and the Queen Charlotte Islands. The boats are comfortable and well fitted up, and in fine weather the delights of the sail from Vancouver northward through the inside passage have to be experienced to be realized. The great many waterways intersecting the group afford access to a relatively large area, but once away from the coast line, traveling may be pursued only on foot, and often with no little difficulty, owing to the decayed vegetation covering the surface. Outfits and supplies for parties working in the interior are transported when waterways are not available, by packing on men's backs, which greatly increases the cost of exploration and prospecting, as well as adding to the difficulty of traveling.

HISTORY

Published authentic information about the Queen Charlotte Group is meagre, and is almost wholly contained in the reports of the Geological Survey of Canada. The best general account of the islands is that given by Dawson[2] who examined the group in 1878. Besides fully treating the geology, Dawson gives an outline of the history of the group, and an account of the natives, the Haida Indians.

Dixon, in 1787, named the group after his ship, the *Queen Charlotte*, and also named several of the islands and surrounding waters. Before this time, they had been visited by several Spanish expeditions, and it is possible that DeFonte, in 1639, sailed among the islands.

A short chronologic outline of the history of the group is given below. The first well authenticated visit seems to have been that of Ensign Perez, who reached the islands on July 18, 1774. After Perez, several other Spaniards visited the group, and many of the place names of today bear witness to the fact. The fur trade was the main attraction for the early navigators, and on the decline of this industry (to quote Dawson), "attention was . . . . withdrawn from the islands until 1852, when the Hudson Bay Company dispatched a party of men . . . to discover the locality from which . . . gold had

[1] Published by permission of the Director of the Geological Survey of Canada.

[2] Dawson, G. M. Geological Survey Canada. Rept. of Progress 1878–79, pp. 1B–239B, 14 plates, and geological map of the group.

been brought by the Indians. This was found to be in Port Kuper, or Gold Harbor, on the west coast. The gold was found in a small irregular vein, which was soon proved to run out in every direction. . . . The enterprise was soon abandoned, but the discovery for a time created quite a *furore*—the first gold excitement of British Columbia. . . ."

Coal was discovered at Skidegate Inlet in 1859 by a Mr. Downie, and in 1872 Mr. James Richardson made a report on this coal for the Geological Survey,[1] in response to requests made by Victoria men interested in the proposition. Then followed the work of Dawson in 1878, and nothing more is heard of the Queen Charlottes till 1905, when R. W. Ells made a reconnaissance of Graham Island. In 1912, in response to requests from companies prospecting on Graham Island for geologic aid in interpreting their results, Dr. C. H. Clapp, M. I. T. '05, then of the Geological Survey of Canada, made a three weeks' reconnaissance on Graham Island. Dr. Clapp's work made evident the necessity for a more thorough knowledge of the geology of the coal basins, and the investigation by the writer and his party was undertaken with this end in view. During this investigation able and efficient assistance was given by Mr. S. E. Slipper of Port Arthur, Ontario, and Mr. C. E. Cairnes, of Vancouver, B. C.

Packing

TOPOGRAPHY AND SCENERY

The principal islands of the group are, from north to south, Graham Island (the largest); Moresby Island, with Louise and Lyell Islands lying close to its east coast; and Kunghit, or Prevost Island, the southernmost. Besides these, there are numerous smaller islets ranging in size down to mere reefs, bare only at low tide, most of these being on the east side of the group.

The islands form part of one of the outer, largely submerged ranges of the northwestern Cordillera, and are generally considered to be the northwestern continuation of the submerged range forming Vancouver Island. Except for the northeastern part of Graham Island, which is low and flat, the group forms a rugged series of mountains, separated and indented by steep, intersecting fiords, the whole being called the Queen Charlotte Range. These mountains probably nowhere exceed 6,000 feet in altitude, if, indeed, they ever attain that elevation. Their rugged grandeur is accentuated by the fact that they nearly always start abruptly from sea level, rising in steep slopes and declivities, usually tree clad. The highest peaks are on Moresby Island, in the Sierra de San Christoval, and these, with others on this island, carry snow caps the year round. On northern slopes and in sheltered cirques and coulees snow

[1] Richardson, James. Geol. Survey Canada. Rept. of Progress, 1872–73, pp. 56–63.

Queen Charlotte City, eastern end

lasts over summer at levels down to 2,800 feet.

Characteristic of the Queen Charlottes are the inlets and fiords, two of which cut completely across the group, Skidegate Inlet and Channel, between Graham and Moresby, and Houston Stewart Channel, between Moresby and Kunghit Islands. Especially south of Skidegate Inlet numerous other straight or curved, steep walled, oftentimes gloomy fiords render access to the larger part of the group comparatively easy.

The scenery is always diversified and interesting, and often very beautiful. Along the coasts the combination of rugged mountain, steep, wooded slope, and blue, islet-dotted water, so characteristic of the Pacific Coast of Canada, lacks nothing of its usual charm. Evidences of human habitation are rare. Skidegate Inlet is particularly charming, and the views shown do it scant justice. The western expansion of this waterway, Waterfowl Bay, surrounded by high hills and studded with many little islands as it is, makes a never-to-be-forgotten scene. The abundance of wild life in this bay is noticeable, and from this fact arises the name. Sea-gulls, several varieties of ducks, eagles, and other birds are seen on every hand, while the glossy black head of the contemplative seal, or the curving back of the playful porpoise is a frequent sight for the traveler. In the interior the scenery is of another variety, and its charm (or lack of charm) depends largely on the weight of the pack and the condition of the trail. The dense forest prevents distant views from being seen, even from the hilltops, and, except occasionally, one has to be content with vistas near at hand. The forest, almost wholly conifers, is the dominating feature of interior travel. The open spaces in it, the muskegs (later described), but serve to accentuate its hold on the land. Burned areas are almost unknown, owing to the moist climate, and because lumbering as yet has not made inroads on the trees, and everywhere the untouched growth of centuries meets one's gaze. If there is a "forest primeval" in Canada, the Queen Charlottes may lay claim to it.

The view from Mount Etheline, southeast of Yakoun Lake, in the south central part of Graham Island, is impressive in the tremendous expanse of forest-clad

mountain, valley and plain that it discloses. From this high point, at an elevation of 2,590 feet, nearly the whole of northern and eastern Graham Island may be seen, as well as Hecate Straits and the coast ranges of the mainland of British Columbia and Alaska. From the summit of Mt. Kahgan, a sharp peak which overlooks Skidegate Inlet, and with

Eagle totem pole, east end Maude Island

an elevation of 3,280 feet is the highest point in south central Graham Island, a wonderful outlook is obtained. Skidegate Inlet is spread out below like a map, and the islands and headlands appear as if etched against the background of the sea. Westward the extremely wild and rugged Queen Charlotte Range crosses from Moresby to Graham Island, and hurries northward, in steep serrate peaks, to die out in the northern part of the island.

Any account of the group would be incomplete without mention of the magnificent hard-packed sea beach on the northern coast of Graham Island, extending southwestward from Rose Spit. This is, doubtless, the finest beach in Canada.

CLIMATE, FLORA AND FAUNA

It is almost a characteristic of the northern Pacific Coast that the combination of high mountain ramparts, and the prevailing moisture-laden winds from the Pacific cause considerable local variations in climate. This is well illustrated in the Puget Sound region, and also in the Queen Charlotte Islands. The west coast is markedly wetter, and has more gloomy days than the east coast, and in the wider northern islands their western and central portion gets more rain than the northeastern lowland. The climate of the whole group, though thus locally varying, may be described as mild, extremes of heat and cold being seldom experienced in the lower levels. The summers are cool, with considerable dark weather and rain, but also with abundant sunshine. The autumn is very wet, but the winter is said to be mild, with considerable fine weather and less snowfall than Vancouver. Residents of Queen Charlotte City state that overcoats are seldom worn.

Vegetation is abundant. The principal forest tree is hemlock, usually not attaining great size, as trees go on the coast, perhaps averaging less than three feet in diameter. Besides hemlock, cedar, both red and yellow, and spruce are other commonly occurring forest trees while alder, yew, jack pine and mountain hemlock are also found. Most of the spruces are magnificent trees, some of them being eight feet in diameter at five feet above the ground, and towering to 300 feet in the air, carrying their size well up the stem. The yellow cedar is a wood worth special mention. It is light lemon yellow or cream color, extremely close grained, though not very hard, and works beautifully with edged tools, and takes also an

Muskeg on Wilson Trail

excellent polish. For interior finishing or furniture, this wood is very well adapted, and the best lumber comes from the Queen Charlottes. It does not occur in large stands (the same may be said of the spruce), and at present is not logged to any extent.

Undergrowth, except in the valley bottoms and on coastal lowlands, is not excessively abundant. Over the uplands, the principal shrub is a scraggly huckleberry, that delays, but does not seriously impede progress, and even this is sometimes lacking. In the low areas, various shrubs grow very thickly, including huckleberries, salmonberries, devil's club, etc., and traveling here is often slow and arduous. Extracting the insinuating thorns of the devil's club from the hands and other parts of the person is one of the constant diversions of the sojourner in the forests of the group.

The surface of the ground, encumbered as it is by layers of dead trees and moss, is usually very rough, and a secure footing is not always obtainable. The trees often raise themselves on buttressed roots above the lower soil level, causing hollows to form around and under the roots, which occasionally trap the unwary. It is curious, also, to see a prostrate tree trunk the site of a whole row of younger trees, these parasitic hedges often attaining considerable size. As some one remarked, "On the Queen Charlottes the woods are three tiers deep." Rank growths of fireweed, bracken, and such weedy annuals are common in the more sunny places, and this sort of vegetation grows very rapidly, forming in some cases thickets very difficult and disagreeable to penetrate.

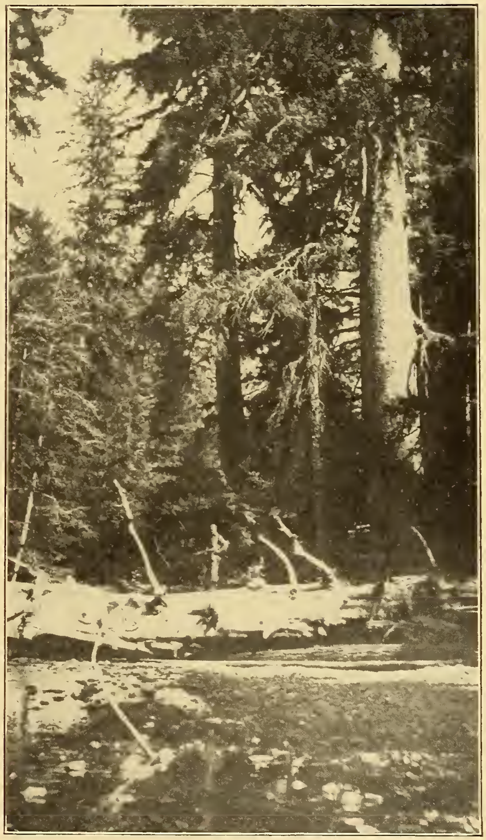
The features termed muskegs merit a word of description. They are of frequent occurrence and of widely varying size. They form wherever there is a break in the slope of the land, causing a bench and impeding drainage, and very large ones form on the flat topped elevations in the interior. It is not necessary that the bench or flattened area be level, for the surfaces of these muskegs at times slope as much as 15° from the horizontal. The muskegs are open spaces, frequently dotted with trees, either isolated or in straggly patches. The surface of the muskeg is a tough, matted peaty mass of decayed grasses, moss, and stems, interlaced with the roots of the plants growing on the top. These plants are various

grasses, with broad leaved plants, mosses, Labrador tea, low-bush blueberries, squawberries, etc. A low, bushy pine, mountain hemlock, and stunted jack pine are the usual trees on the muskegs. Scattered irregularly over the surface are stagnant pools of water, filled usually to within about a foot of the general level, and containing immediately below the water surface a flocculent mass of brown decayed vegetable matter, thickening with depth. The depth of these pools is considerable, and it is easy to thrust a pole down ten feet or more in many of them. It is common to find the water in pools not five feet apart remaining apparently constant at levels varying by as much as a foot, due to the very slow seepage through the peaty material below the surface.

These muskegs, constantly wet as they are, do not allow of rapid walking, but are preferable as routes for trails to the unbroken forest, as the surface is smooth, and the impedimenta of roots and underbrush are lacking. The muskegs are, doubtless, caused by the moist, equable climate, permitting a very rapid growth of vegetation. Some of these open spaces are almost half a mile in diameter, and their wind swept appearance on a stormy day is desolate and forbidding. In fine weather, however, they form a welcome interlude to the monotony of the forest.

The water life of the coast has been mentioned. Halibut and salmon abound in the surrounding seas, and are sought after for canning purposes. In the forests, wild life is not abundant. Black bear are common, but they are the only species of frequent occurrence, and although their signs are continually met with, the animal himself has a remarkable ability for effacing himself from the landscape, and when surprised usually disappears with ludicrous but effective despatch. Marten and probably otter are found, but elk and deer are not at present indigenous to the group, though a few of the latter have been introduced by the provincial government. Their absence is the more remarkable because on the islands fringing the mainland, deer are found in abundance. Wild cattle were formerly abundant on Graham Island, but now are very scarce, though a few were killed last summer near Rose Spit.

Song birds are rarely met with, although a note like that of a song sparrow is heard once in a while. Hummingbirds, those startling iridescent bits of animation, are frequently found, and one never seems to get accustomed to the abrupt whirring announcement of their presence.



Spruce trees on Hidden Creek

SETTLEMENTS AND AGRICULTURE

Queen Charlotte City, on the south end of Graham Island, with a population not exceeding 150, is the largest settlement on the islands. At Skidegate Village, about three miles east of Charlotte, there are a few houses, and oil

Skidegate Indian Village

works of the B. C. Fisheries Company. Alliford Bay, on the southern side of the inlet, is a small hamlet owing its existence to the canneries of the same company. Skidegate Indian Village, near the entrance to the inlet of that name, is populated almost wholly by Indians. Masset, and Naden Harbor, on the north coast, and Queenstown on Masset Inlet are some of the other villages on Graham Island, while Pacofi, Lockeport, Ikeda and Jedway are settlements on Moresby Island.

Ranching is confined to the northeastern lowland of Graham Island, though a few small ranches are worked on some of the islands in Skidegate Inlet. Graham Island, in common with some other western communities, has suffered at the hands of unscrupulous real estate boomers, and various misrepresentations, both favorable and unfavorable have been given publicity. If local conditions in regard to agriculture are intelligently studied, men with ability and some capital to start operations should make a success of farming. Several ranchers are attaining considerable success with various crops in the northeastern lowland, and at least one man has proved stock farming to be profitable here. Vegetables of excellent size and flavor are grown on Graham Island, the potatoes being especially fine.

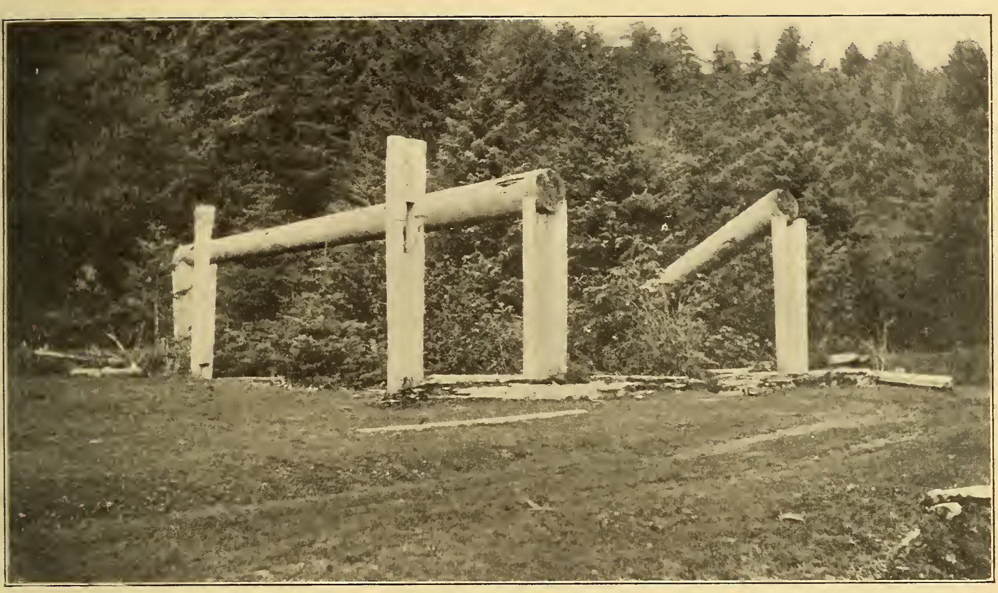
NATIVES

The natives of the Queen Charlotte Islands, the Haida[1] Indians, have been fully described by Dawson in an interesting appendix[2] to his report on the group, and the following account in part abstracted from that memoir.

The Haida nation appears to be one of the best defined groups of tribes of the northwest coast, and their original territory, as far as tradition carries us back, is the Queen Charlotte Group.

The Haidas are markedly fairer skinned than most of the coast tribes, and possess somewhat finer features. This characteristic is at present even more marked than when Dawson noted it, owing to admixture of white blood since that time, and it is startling to see blue-eyed children with yellow hair, playing on the beach in front of the villages. The most striking

[1] Pronounced hy'-dah.
[2] Dawson, G. M. Geol. Survey Canada. Rept. of Progress, 1878–79, pp. 103B–189B.



Framework of old Indian house

departures from European ideas of symmetry are found in the large mouth, width and prominence of the cheek-bones, and the disproportionately large head. The body is not infrequently large and long as compared with the legs, perhaps brought about by the constant occupation of these people in canoes, and their infrequent land excursions.

The native houses are strongly built of large timbers carefully fitted together, although but few of these houses are now to be found, and these more or less ruined. The carved posts, commonly termed totem poles, are especially well developed among the Haidas, and often elaborate and curious, indeed, is their ornamentation.

The permanent villages, very few of which are still inhabited, were generally situated with regard to easy access to the fishing grounds. For this reason they were often in exposed places, but a shelving beach on which canoes could be easily landed was always a necessity. The houses were arranged side by side, and a space remained between the fronts of the houses and the edge of the bank, serving for a street, as well as for the erection of the carved posts. These carved posts are broadly divided into two classes, one variety formerly being found before every house, the other sort having been erected in memory of the dead. The first kind are the more highly ornamental, and are from 30 to 50 feet high, three feet or more wide at the base, and tapering slightly upward. These posts are generally covered with grotesque, somewhat conventional figures, closely grouped together, from base to summit. Models of these posts, carved from a hard, black carbonaceous shale found in the Slate Chuck Valley, are made by the Haidas even to the present time, though they become scarcer every year, as the younger Indians do not take up the arts of their fathers.

The monumental posts have a greater diversity of design. A common form consists of a stout, plain, upright post, round in section, and tapering slightly downwards, one side of the top flattened. To this is affixed a sign-board-like oblong of hewn cedar planks, which may be painted or decorated. Another form consists of a round, upright post with a carved eagle or other figure at the summit. The carving of some of these birds is strikingly realistic. Still other poles are

Looking west over Queen Charlotte Range from Mt. Kahgan

carved only at the base, and run upwards into a long round post with incised rings about four feet apart. The simplest form of post is merely a round straight tree, with the branches and bark trimmed off, and resembling a flag pole.

Many other curious and interesting facts are given in Dawson's account.

While inquiring the names of localities about Skidegate Inlet from one of the older natives, the present writer was interested to learn that the Haida name for Alliford Bay—Ghatz-rrunday, as near as it may be set down—signifies in the language of my informant "sometime, all this place shake (shaking his hands) all same ghatz-rrunday." It seems quite possible that some of the earthquakes, so prevalent farther north in Alaska, may have effected this region not so long ago.

GEOLOGY

The Queen Charlotte Islands have had an eventful geologic career, the story of which may be deciphered from rocks which date back to early Mesozoic times. The oldest rocks exposed belong to the Vancouver Group, largely volcanic in its nature, composed of consolidated ash rocks and lavas but containing also metamorphosed mud rocks and limestone members. This formation was in large part accumulated under water. The Vancouver Group is widespread in the Pacific Coast region of Canada, and is an important geologic formation. After its accumulation it was folded by mountain building forces and later was intruded, and in large volumes replaced by the deep-seated granular igneous rocks of the great Coast Range batholith. These plutonic rocks are generally supposed to be Upper Jurassic in date. On the Queen Charlotte Islands they are exposed in rather small, separate areas at the surface.

After the folding and batholithic intrusion, the mountains formed by the uplift were partly worn away by processes of denudation, and once more, in Cretaceous time, the area was the scene of extensive marine sedimentation. The surface on which the basal rocks of the Cretaceous series were laid down was a very uneven one, probably resembling to some extent the topographic conditions found in Skidegate Inlet today. The Cretaceous sandstones, shales and conglomerates accumulated to a thickness of the order

of 10,000 feet, and many zones are highly fossiliferous. In the lower part of the rocks coal occurs, at a single rather extensive horizon.

After, and to some extent during the building up of this great series of sediments they were invaded by igneous rocks in the shape of sills and dikes, and a second elevation of the group then took place, again causing great denudation, and from much of the surface the Cretaceous rocks were removed. On this surface were poured out great floods of lava in Tertiary times, and volcanic action may have continued throughout most of the Tertiary period. These lavas are associated with marine sediments, so the land then stood somewhat lower than at present. A third great erosion period, continuing to the present time has shaped the topography as now seen, and a relatively recent slight uplift has taken place. Cretaceous and Tertiary rocks are now virtually confined to Graham Island, the islands south of Skidegate Inlet being formed of pre-Cretaceous rocks, mostly belonging to the Vancouver Group.

Coal, the investigation of which was our particular object, has been found at several localities on Graham Island, and around Skidegate Inlet. The most important localities are on Graham Island, at Cowgitz and in the Slate Chuck Valley, near Skidegate Inlet; and at Camps Anthracite, Trilby, Robertson and Wilson in the interior. At all of these localities the coal is of lower Cretaceous age, and occurs at a single horizon, repeated by folding. It is possible that the coal at Camp Wilson occurs at a lower horizon than that in the other basins. The coal at Cowgitz, Slate Chuck and Camp Trilby, near Yakoun Lake, has been altered by some sort of volcanic action to an anthracitic variety. At Camps Robertson and Wilson, the most promising prospects, the coal is bituminous, rather high in ash. The structure of the coal basins is synclinal, and large faults have not been located; they are rare or absent.

Lignite of Tertiary age occurs at Skonun Point on the north coast of Graham Island, and at other localities also. This lignite is a future resource of value.

Deposits of metallic minerals are almost wholly confined to the islands south of Skidegate Inlet, and, with the exception of the Southeaster and Beaconsfield claims, on Graham Island, none of these were visited by the writer this year. The occurrence of gold at Gold Harbor has already been noted; here the gold is said to occur in a quartz vein in volcanic breccias. In Cumshewa Inlet, several men are actively prospecting a gold-silver-lead deposit, which is reported to be of considerable value. At Copper Bay, between Skidegate and Cumshewa Inlets, is a very old shaft sunk on a copper-bearing vein, and copper is also found at Lockeport, Ikeda, Jedway and Tasoo Harbor.

Prospecting for oil by means of drilling is being carried out at Otard Bay, on the northwest coast of Graham Island. The clay deposits of northern Graham Island are of value, though as yet no high-grade clays have been found.

The writer is indebted to Dr. F. H. Lahee for criticism and advice in the preparation of this article.

THE STRENGTH OF ANTS

An ant can carry a grain of corn ten times the weight of its body; while a man or horse can carry loads only about equal to its bodily weight.

It is not a fact, however, that the ant is greatly superior in strength. If an ant should grow to twice its original size, still retaining its geometrical and histological structure, its volume and accordingly the weight of its body would increase eightfold. Although the muscles grow to twice their original dimensions, the increase in length does not increase the strength, which is proportional to their cross-section, and the ant would only be four times as strong as before. As it now carries but five times its weight, however, it is relatively only half as strong.

It is calculated that the same ant developed to the size of a man would only be able to carry 1-100 of its own weight, instead of ten times its own weight.

EYE DEFECTS OF BACKWARD CHILDREN

AN OVERLOOKED OBSTACLE TO THE MENTAL DEVELOPMENT OF THE CHILD THAT IS RESPONSIBLE FOR MUCH SUFFERING AND LOSS OF MENTAL POWER

BY MORTIMER FRANK

The increased demands of school life and the rapid advances in educational methods have made the physical well-being of the child a more and more important factor in education. Educational institutions of today protect and develop the physical condition of the child, side by side with the mind, but the dull and backward pupil who is mentally deficient because of improper functioning of the eyes is more or less neglected. There is no physical defect that interferes with or even prevents the progress of a child in school so much as defective vision and there is no defect so easily and cheaply remedied. Children with defective eyes must be divided into two classes: first, those who are really mentally deficient, and whose defective eyes simply make their condition more pronounced, and, second, those whose minds are normal, but who are dull and backward because of their inability to overcome their eye defects without a great or often impossible expenditure of nerve force. It is for the pupil of this latter class that the greatest efforts on our part should be exerted. They are the children for whom and upon whom especial thought should be bestowed. Within a few years reading was taught by a slow and cumbersome method. Few children enjoyed the reading of a book until the third school year, but today this is all changed. By the present methods of teaching reading the child reads simple books at home for his own pleasure before the first year is ended. The loss of nervous energy necessitated by reading and writing at the ages of from 5 to 8 years is an unwarranted drain upon the health of the child. Instead of giving the child the free and vigorous movements of the larger muscles at this age, the use of the smaller ones with their finer adjustments for reading and writing are brought into play.

The sacrifices caused by this premature strain in this age of rush and the influence upon the one organ—the eye—which is abused more than any other, can not be over-estimated. Few realize how enormously complicated is the act of reading and how many difficulties must be conquered before the printed word becomes the spoken word, never stopping to consider that all this mysterious and difficult adjustment must be made in early childhood. Imagine for a moment the immense difficulty the young child must experience in learning to direct and control the necessary movements of the eyes in the act of reading. The effort made to follow the printed line from side to side, to fixate particular sentences, words or letters hampered by the inherent physiologic incompleteness of childhood. From observation and examination of a very large number of foreign-born children who frequent the eye department of the West Side Hebrew Dispensary, I am convinced that not only are defective eyes very common, but, owing to neglect, lack of proper food, air, care and hygiene, these defects are much more serious on the average than among native-born. Examine these eyes and you will perhaps find corneal opacities or a congenital cataract or, what interests us particularly, some remediable error of refraction. Place this child in a school where his defects are overlooked and what results? An immense amount of physical suffering, expressed or endured without complaint. In childhood and early adolescence, the plastic period of growth, the eye ball is soft and yielding, and the strain

of the ciliary muscle and those of the globe are productive of changes in its shape. The hyperopic eye is the most frequently observed in these cases and the one entirely misunderstood by parents and teachers. Unless the hyperopia is of high degree the child can often read the 6/6 or 6/5 line at 6 meters as readily as the child with normal eyes, and for a time can often read the finest type at 12 inches. This eye, when at rest, has its distance image formed back of the retina, and to see clearly must use its power of accommodation oftentimes much in excess of the amount necessary for the normal eye to accommodate at the ordinary reading distance. When the eye is used for close work there is the usual accommodative effort for the near point, added to the amount already in use for distance. This combined effort is much too great. The ciliary muscle can not keep it up and so the accommodation soon relaxes, the type becomes blurred and the book is dropped. A child with such eyes finds it impossible to keep the print clear, no matter how large, and will finally cease to make any effort, with the result that he fails to keep pace with his fellow-pupils. If such a child is naturally dull, the inability to study makes the dulness very much more marked.

The high degrees of hyperopia are easily detected, as such eyes can not accommodate sufficiently to get clear distant vision, and, in order to get as large a retinal image as possible, holds the school book within a few inches of the eye. These cases are often wrongly diagnosed as myopia and sent to the ophthalmologist as such. Pass from this type to another where the hyperopia is of low grade and the least easily detected. This is the child who has excellent vision, learns readily and is interested in things about him, but neglects his studies, and his failure to do well at school is attributed to deliberate neglect on the part of his overworked teacher. He begins the day at school well enough, is bright, but has a reputation of being lazy, idle and mischievous. He tires soon of his work and is constantly reprimanded. The difficulty with him is that, while his eyes are keen enough for transient distant vision, his eyes tire after a short application for close work and begin to wander. He can not keep up on account of his inability to overcome his eye defect without a great or often impossible expenditure of nerve force. If he is closely watched each afternoon he has headache, pain or more or less general discomfort in the eyes. Such a child can not possibly have the pleasure in learning a normal child should have.

If we consider eyes normal because a child can see the blackboard from the back seat and read the normal line of the test-type, we are overlooking a large number of children whose eyes are causing them great suffering, for the child with a moderate amount of astigmatism may also by an effort of accommodation, or by partly closing the eyelids, be able to pass the school test, as does a child with normal distant and near vision. In astigmatism the curvature of the cornea is not uniform, being greater in one meridian than in another. Eventually the great effort to maintain this vision soon produces general discomfort, he falls behind in his class, there is a disinclination to study, he hates school and becomes a truant. The backward child with myopia demands the greatest care. Doomed often from childhood in failing to have his childish imagination stimulated by the beautiful things in Nature, his work is bounded by a few inches beyond his nose. He can not see to play the games of his schoolmates, and, though put in a seat close to the blackboard, derives slight benefit from it, and what is seen is obtained only with a strain. Later on, when information can be derived from books, there is an added danger from his myopia becoming progressive. He sees to read by holding the print close to his eyes, but loses tremendously by reason of his defect. The eyes are more or less diseased and consequently become more and more myopic until vision is greatly reduced, and the earlier we can correct the refractive anomalies by the aid of proper glasses the more we shall help their eyes and brain.

Even worse off is the child whose sight

is impaired by opacities resulting from disease or neglect. With his distant vision as poor as the myope he has added the spotting and distortion of near objects by the constant shadow of his opacity. He earns a reputation for stupidity, idleness and inattention and is the butt of his better-equipped mates. Less common than refractive errors, but often dependent upon them, is a lack of perfect balance of the extraocular muscles which make possible the movements of the eyes. Activity on the part of these muscles is excessively fatiguing and any cause which would affect their nerve centers would, in turn, affect the eye movements by which reading is made possible. The backward child with whom nerve exhaustion is the usual condition finds it a task beyond his strength to follow with accuracy and speed the mysteries of the printed page and is constantly losing his place and slipping off the line. Every child struggling with one of the foregoing conditions is working at a disadvantage. The demands of school life are so great that even a normal eye fails, and refractive errors develop, and it is no wonder, then, that the imperfect eye must suffer. I personally have seen many apparently dull and backward children transformed into bright, energetic pupils by the benefits derived from improved eye conditions. The number of dull or backward children with imperfect vision is entirely too great to be accounted for on the ground of mere coincidence.

In view of the fact that investigation showed that 60 per cent. of children examined in the Philadelphia schools had eyestrain or defective vision, the city in 1907 established an ophthalmologic division of the bureau of health. The city council appropriated $300 for glasses for children unable to pay for them, and with this money 354 children were fitted with glasses. These children without glasses could not read from the blackboard and could not see the print in their books; in many instances they were thought backward and often mentally deficient. The correction of these defects by the fitting of proper glasses was followed by remarkable improvement in the work and conduct of the pupils. Children in special schools were enabled to return to the regular schools. Dr. Joseph L. Neff, director of the Department of Public Health and Charities, considers that the report of the first three months' work has demonstrated that many so-called mental defectives and incorrigibles do not really belong in that category. The report emphasizes the fact that the expense incurred is more than counterbalanced by the increased worth of an educated citizen over an illiterate one who may become a public charge, or whose earning capacity is so curtailed that he can contribute but a small amount to the support of the state. Dr. Neff believes that in many cases such children would have joined the criminal classes or in some way have become a burden on the community.

From a study of the subject and my personal experience I would offer the following conclusions:

1. That refractive errors are unusually frequent among backward children.
2. That the correction of these defects by the fitting of proper glasses is followed by remarkable improvement of the mental power and allows the apparently backward child to keep up with his mates.
3. That it would be decidedly good policy to have the eyes of all children with real or apparent mental deficiency thoroughly examined as a matter of routine.

A RAILWAY IN ICELAND

Plans are now complete for the first railway in Iceland. It is to be run from the capital, Reykjavik, over the Thingvalla plain to the Olfusa bridge, a distance of about fifty-eight miles, and will cost about $1,000,000. The railroad will be continued ultimately to Thorsjaa, and from there one branch will lead to the geysers and the other to Oerbak.

The present methods of traveling are extremely primitive, the roads being few and poorly maintained, and with few bridges over rivers. In general island journeys are made on horseback, over bridle-paths or trails, and the streams have to be forded.

THE MYSTERIOUS EEL

ITS LIFE HISTORY HAS BEEN A PUZZLE TO NATURALISTS FOR CENTURIES AND THERE IS A GREAT DEAL YET TO BE LEARNED ABOUT IT

A DEEP mystery surrounds the lives and habits of many familiar fishes, and the deepest of all, with few exceptions, enveloped the life history of the eel for thousands of years. Theories, rank and fantastic, curious and impossible, environed the snakelike fish, and some are still believed, and much of the mystery has not to this day been entirely cleared away by scientific men.

Mr. W. E. Meehan, commissioner of fisheries of Pennsylvania who writes interestingly about them in the New York *Sun*, says that Aristotle, who for centuries was venerated as the greatest of scientific men, declared that eels were sexless and were produced spontaneously from "the entrails of the sea." Pliny agreed that the fish was without sex, but advanced a different theory of generation. He declared that a mature eel rubbed its body against a submerged rock, and the slime which was detached separated into small particles and became imbued with life.

Nowadays with a sense of superior knowledge people smile over the fantastic theories of Aristotle, Pliny and many other scholars of later date, but what they proclaimed was scarcely more grotesque or absurd than a belief widely current today, that eels are developed from hairs of horses.

Some 1,200 years after the death of Pliny scientific men began to assert that eels do possess sex, but they held that the young were born alive from the female. A careful search for verification followed which lasted for nearly a century before the sex theory was demonstrated. It was just a year after the Declaration of Independence that Mondini, a distinguished Italian naturalist, discovered a female eel, and demonstrated clearly that the eggs were deposited and the young hatched in the same way as those of other fishes.

The male eel was not identified until 1873. Before that time and after Mondini's discovery the lamprey, which, by the way, is not a true fish, was generally believed to be the male of the eel, and even at the present time there are many intelligent persons who still maintain this idea.

There remains much to be learned of the life history of the eel, but what is known is of deep interest. Some of the facts are almost as astonishing as the theories held by our forebears.

The common eel is a fresh water fish which for some undiscovered reason requires salt water in which to spawn. In this particular it is the reverse of the shad, for that delicious food fish belongs in salt water but must when spawning time comes make its way into fresh water. It is because of this spawning requirement that eels are rarely found in the Allegheny River. The headwaters of that stream are too far from the Gulf of Mexico for the fish to make a trip down and up within twelve months.

The great journey to the sea begins about the middle of August. From every pond and mountain lake, from every stream, brook or waterway, eels swarm into the principal rivers and make their sinuous way southward by millions, all with one common purpose, to reach the mud banks in the shallows of the bay, there to spawn.

Some of the vast aggregation do not go and the question may well be asked, Why? The answer is apparently simple. The stay at homes are believed to be barren, or have not reached the spawning age and therefore are without the instinct and impulse to turn seaward. While this

theory has not been definitely proved, it is plausible.

Only capture or death can prevent the eel, having once started seaward, from continuing its journey and fulfilling its mission. Nothing could more forcibly illustrate the truth of the great doctrine enunciated by the late Thomas Meehan before the American Association for the Advancement of Science, that "self-sacrifice plays as great and important a part in nature as the 'struggle for existence,'" for at the end of the journey death awaits the majority.

The eggs of the eel, which are very minute, do not develop until brackish water is reached; then ripening begins, and it is completed within a few weeks. It is because the ova are immature and also very minute while the fish are in fresh water that the secret of sex was so long concealed from scientific men as well as laymen. Not even the enormous number of eggs which every female possesses, and it runs into the millions, gave assistance to their detection.

Often fishermen are aware of habits unsuspected by scientific men who make a study of ichthyology, and one phase of eel life affords a good example of this. The general impression among scientific men is that all eels die after spawning. This statement was made before an association of the most eminent fish culturists and ichthyologists in the country only three years ago by a man who had made a special study of the eel, and who was amazed when his statement was controverted by a fish culturist from Pennsylvania.

While many river fishermen know nothing of the spawning habits of the eel and numbers of them believe absurd stories concerning it, all know from actual experience that every spring there is a run of mature eels up stream, a run of huge dimensions, and they catch them by setting their nets down instead of up stream. Thus while a large proportion of eels may and doubtless do die, a goodly number survive.

The progress of the fish from the sea to the haunts they left the summer before is as persistent as that on their way to salt water. If they come to a dam, a waterfall or anything in a river or stream which they cannot surmount they do not hesitate to leave the water on a dark rainy night and take to land, wriggle around the obstruction and continue their journey up stream.

It is declared that if when on land they meet with food they will seize and eat it. One careful investigator says that he has seen eels crawling across a plot of short wet grass. stop, seize and swallow earthworms.

The eel is a carnivorous fish and to some extent a scavenger, and while classed among the slower moving fishes it has acquired much skill and exercises great ingenuity in pursuing and capturing its prey. Not even the lightning-like moving trout and pickerel can always be sure of escape.

The eel also shares with most other fishes a great fondness for fish spawn. Heartbreaking tales are related by men who want destructive devices permitted, of the destruction eels wreak in this particular, and they invariably conclude by arguing that although the baskets and outlines and sundry other forbidden fishing devices may catch other fish also they should be permitted so as to exterminate the eel. But the eel, like other creatures that have a bad name, is less black than it is painted.

Two other characteristics of the eel are not generally known, and they are very interesting. One is that it, in common with other fishes, has scales. This statement is likely to be received with incredulity by the vast majority of those familiar with the slimy, serpentlike fish who have had frequent and abundant evidence of its superlative knowledge of intricate knot tying in fishing lines; but it is nevertheless a short statement of a scientific fact. The scales are microscopic and imbedded in a thick, mucous skin and invisible to the naked eye.

A second characteristic not universally known is the presence of an active poison in the blood of the eel, a poison sufficiently virulent, it is said, to prove mortal to a human being inoculated with it. Fortunately the poison is not seriously harm-

ful if taken into the stomach and it entirely disappears when subjected to heat; consequently the publication of this peculiar feature of an eel's makeup need not lead a person who enjoys its flesh to deny himself his favorite dish.

As a concluding note it might be stated of this fish, which has given so much trouble to scientific men, and also to unscientific men and boys who have had their lines helplessly tangled while fishing, that the stay-at-home eels do not disport themselves in the water throughout the winter, but with the coming of cold weather bury themselves in the mud, where they sleep comfortably until spring.

LIFE FROM LIFELESS MATERIAL

In an address delivered before the British Association, President E. A. Schäfer said:—

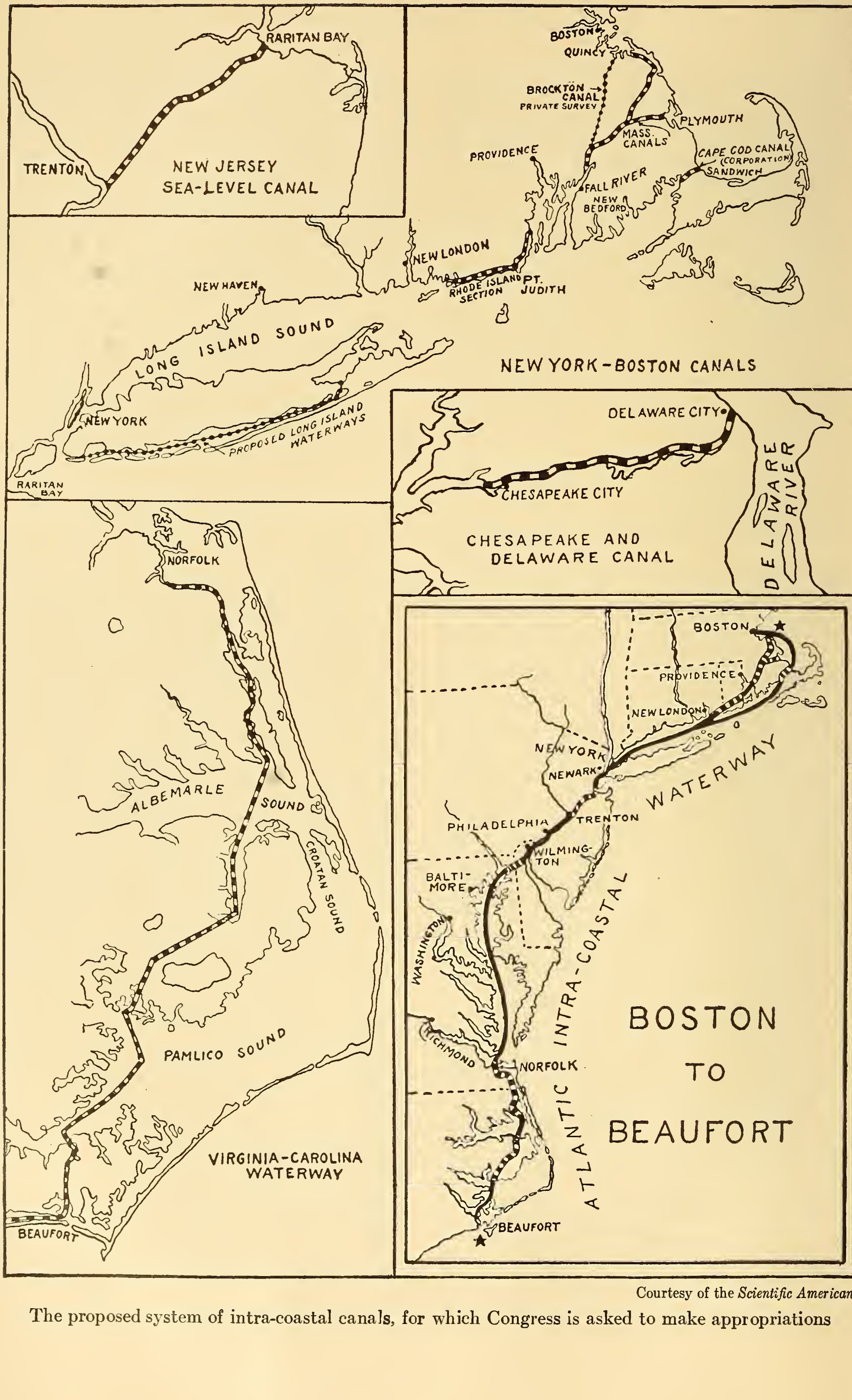
There is, it must be admitted, nothing new in the idea that living matter must at some time or another have been formed from lifeless material, for in spite of the dictum *omne vivum e vivo*, there was certainly a period in the history of the earth when our planet could have supported no kind of life, as we understand the word; there can, therefore, exist no difference of opinion upon this point among scientific thinkers. Nor is it the first time that the possibility of the synthetic production of living substance in the laboratory has been suggested. But only those who are ignorant of the progress which biochemistry has made in recent years would be bold enough to affirm that the subject is not more advanced than in the days of Tyndall and of Huxley, who showed the true scientific instinct in affirming a belief in the original formation of life from lifeless material and in hinting at the possibility of its eventual synthesis, although there was then far less foundation upon which to base such an opinion than we of the present day possess. The investigations of Fischer, of Abderhalden, of Hopkins, and of others too numerous to mention, have thrown a flood of light upon the constitution of the materials of which living substance is composed; and, in particular, the epoch making researches of Kossel into the chemical composition of nuclear substance—which in certain forms may be regarded as the simplest type of living matter, while it is certainly the *fons et origo* of all active chemical processes within most cells—have shown how much less complex in chemical nature this substance may be than physiologists were a few years ago accustomed to regard it. On this and other grounds it has lately been independently suggested by Prof. Minchin that the first living material originally took the form, not of what is commonly termed protoplasm, but of nuclear matter or chromatin: a suggestion which seems by no means improbable.

WHAT IS SLEEP?

In an article on "Sleep" Dr. Boris Sidis says:

"Sleep is not a disease, not a pathological process due to the accumulation of toxic products in the brain or in the system generally. Sleep is not an abnormal condition, it is a normal state. Like the waking states, sleep states are part and parcel of the life-existence of the individual. Waking and sleeping are intimately related—they are two different manifestations of one and the same life-process —one is as normal and healthy as the other. One cannot help agreeing with Claperède's biological view that sleep is a positive function of the organism, that sleep belongs to the fundamental instincts. As Claperède forcibly puts it: 'Sleep is a protective function, an instinct having for end, in striking the animal with inertia, to prevent it from arriving at a condition of exhaustion. We sleep, not because we are poisoned or exhausted, but so that we shall be neither poisoned nor exhausted.' "

A California transmission company patrols its high-tension lines leading out of Oakland in an aeroplane. A lineman equipped with repair apparatus will ride with the aviator, and the pair will take trips twice a week. The headquarters of this novel inspection crew are to be established at Sacramento.



Courtesy of the *Scientific American*

The proposed system of intra-coastal canals, for which Congress is asked to make appropriations

A GREAT INLAND WATERWAY

Before retiring as chief of engineers of the army, Brigadier-General Bixby made a strong recommendation to Congress, advocating the construction of a system of intercoastal canals to form an inland waterway between Boston, Mass., and Beaufort, N. C.

Such a waterway would be of untold value to coastwise traffic as well as of great importance to the naval and military arms of the government; and the coastal conditions are all in favor of this project.

This enterprise has been advocated for many years by the Atlantic Deeper Waterways Association, through whose efforts the appropriation was made by Congress, which provided for a survey by army engineers to determine the feasibility of the scheme, and to estimate on the probable cost of construction. This commission was also to report as to whether the amount of traffic would warrant the construction of a complete system of intercoastal canals, and upon the naval and military advantages of this inland waterway in case of war. The other problem was the cost, size and type of canal to meet all conditions, present and future.

It is to be understood that this is intended to be the beginning of a greater scheme for building a line of canals from Boston entirely around the Atlantic and Gulf coasts to the Rio Grande.

The special board has been investigating this matter for a period of seven years and its conclusions, supplemented and amended by that of General Bixby, are as follows:

For the first section of the canal two alternatives were offered—the purchase of the privately owned Cape Cod canal or the building of a government-owned canal from Boston to Narragansett Bay, the cost of which would be about $10,000-000. The conclusion reached was that there is no immediate commercial necessity sufficient to justify the construction of a government-owned canal at the present time.

The second link is known as the Narragansett Bay-Long Island section. This route leaves Narragansett Bay at Bissel's Cove, following a series of tidal streams and lagoons to Long Island Sound, opposite Montauk Point, avoiding the dangers of navigation around Point Judith.

It was estimated that a canal 18 feet deep would cost about $12,000,000; while one 25 feet deep would cost twice as much.

The final conclusion reached was that such a canal would afford little saving of distance over the route via Long Island Sound, and that boats would probably prefer the latter except in stormy weather.

In cutting a canal from New York to the Delaware River, it was found inadvisable to purchase the existing Delaware and Raritan Canal, and a new sea-level canal was recommended, which would have a depth of 12 feet, sufficient for floating one and two-thousand-ton barges. The expense of this canal would be about $20,000,000, and it should be so built as to allow an economical enlargement to a depth of 25 feet, and so designed that it can be changed from a lock to a sea-level canal.

From the Delaware River to the Chesapeake Bay the route was surveyed along the line of the present Chesapeake and Delaware Canal. The building of a canal along this route would cost about $10,000-000, and the board recommended that the Chesapeake and Delaware Canal be acquired at a purchase price of $2,500,000. This canal is 10 feet deep and of the lock type. An appropriation of $8,000,000 was recommended to transform this canal into a sea-level with a depth of 12 feet throughout.

All practical routes from Norfolk to Beaufort were surveyed and the one selected was the route via the Albemarle and Chesapeake Canal, Currituck Sound, Alligator River, Rose Bay and Adams Creek. It was recommended that the

Albemarle and Chesapeake Canal be purchased for $500,000, $2,235,000 to be spent in improving it, and increasing its depth to 12 feet.

From Albemarle Sound to Beaufort inlet the estimated cost of construction is $2,600,000.

Congress has already made a start in the construction of this intercoastal canal by appropriating $800,000 for the Norfolk-Beaufort section, $500,000 of this amount to be spent for the purchase of the Albemarle and Chesapeake Canal.

In brief, the recommendation abandons for the present the section from Boston to New York, and recommends that Congress appropriate $30,000,000 for the construction of a 12-foot canal between New York and Norfolk, the canal from Norfolk to Beaufort having already been authorized.

FUTURE OF THE WIRELESS TELEPHONE

In a recent address Professor Elihu Thomson said:—

"The practical success of the wireless telephone depends upon our ability to control the voice waves and to vary in accordance therewith the energy given out by the transmitting antennæ, and to do this with a fairly good output of energy. Much progress has been made in this department of wireless work, and such telephony between Europe and America may yet become practicable. Methods are being worked out whereby it may be possible to mould by microphone, outputs of many kilowatts of energy so as to have them vary with the voice waves, and when this is done, many problems, the solution of which now seems remote, may be solved and the results prove of great practical value to the world."

LARGEST MARINE DIESEL

The recent arrival of the ship *Wotan* in New York Harbor, is of interest because the ship is propelled by a single-screw, six-cylinder, two thousand horse-power Carels-Diesel marine engine. Other motor ships that have come to this port, were driven by two engines of six or eight cylinders, whose gross capacity was about 2,000 h. p. and in each case they were supplied with injection air by additional engines. The motor of the *Wotan* is a six-cylinder engine with an injection air compressor on the engine. This is the largest marine Diesel engine in service, and the good record of the ship on her maiden voyage is another proof of the reliability of this type of drive.

SCIENCE CONSPECTUS

VOL. IV 1914 NO. 2

THE RADIUM SITUATION

THE NATURE OF RADIO-ACTIVE MATERIAL AND THE RADIUM RESOURCES OF THIS COUNTRY—STARTLING TESTIMONY AS TO ITS THERAPEUTIC IMPORTANCE

A LECTURE BY CHARLES L. PARSONS

IN ATTEMPTING to cover the radium situation as it exists today in the United States, a speaker cannot hope to more than skim the surface or give other than a general summary of the subject. In order that you may understand it clearly, I shall touch briefly not only on the physical and chemical properties of radio-active material, but shall also take up the economic side of the question, such as the occurrence of radium, the development of the ores in this country, and the value of radium in the treatment of disease.

By radio-active material is now generally meant that class of substances such as uranium, thorium, and their decomposition products, all of which possess the property of spontaneously emitting radiations and of giving off a continuous supply of energy without apparent stimulus or exhaustion.

The emission of energy by these substances cannot be retarded or accelerated; the energy comes from an unknown source; obeys unknown laws; and apparently comes out of nothing. Radium, for example, emits per unit mass more energy than any sun or star: if the sun were all radium it would give off heat and a light probably one million times greater than the present orb. This wonderful ebullition of energy by radio-active material has enabled chemists and physicists to discover elements that would otherwise have remained unknown, and to measure minute quantities of these elements with an accuracy far greater than the imagination can conceive.

When Henri Becquerel, in 1896, discovered, almost through accident, that uranium and its salts possessed the property of giving off rays that affected a photographic plate through material ordinarily opaque, no one could realize the effect the discovery was to have upon our conception of matter. Following Becquerel's announcement, there was much interest aroused in the scientific world as to the reason for these radiations. One theory proposed, among others, was that the ores of uranium contained a new substance with unusual properties. Professor and Madame Curie, working upon this supposition, analyzed with care the residues from pitchblende ore used in the extraction of uranium, as these residues had been

shown to be more radio-active than the ore itself. In the course of their work, they found that when the barium which the material contained was separated, it carried with it a large part of the radio-activity, and after many fractional crystallizations, by which this radio-activity was gradually increased, they were able to announce in 1898 the existence of a new element to which they gave the name "Radium."

Even preliminary notice of the properties of this element so startled the scientific world that it has not yet fully recovered its equanimity. Many scientific investigators have since studied radium, but the scarcity of the element has rendered progress slower than would otherwise have been the case. Among those who have developed our knowledge of the subject, Sir Ernest Rutherford, recently knighted for his discoveries, stands pre-eminent. His book on "Radio-active Substances and their Radiations" recently issued, will always remain a scientific classic.

In this connection it might be mentioned incidentally that, although radium was discovered in the eastern hemisphere, the western hemisphere should have the credit of developing a large portion of our present knowledge of the subject. This fact is not as widely realized as it should be. Rutherford and his distinguished co-worker, Soddy, both acquired their reputations at McGill University, Montreal, from which they later went to the University of Manchester and the University of Glasgow. Besides these, Boltwood of Yale, McCoy of Chicago, Schlundt of Missouri, Duane of Harvard, and Moore and Lind of the Bureau of Mines are thoroughly appreciated abroad for their contributions to the subject. Credit for many of the facts quoted in this paper should be given to the published works of these scientists.

It will be necessary to pass rapidly over some of the known facts. Uranium has been shown to be spontaneously decomposing, into definite products, the amounts, life periods, and radiations of which are shown in the following table:

TABLE I (Rutherford, page 468)

URANIUM SERIES

Uranium series	Atomic weight	Weight per kilogram of uranium	Half-value period	Rays	Range of α rays 15° C
Ur { Uranium 1	238	10^6 mg.	5×10^9 years.	α	2.5 cms.
↓ Uranium 2	234	196 " (?)	10^6 yrs. (?)	α	2.9 "
↘ Ur Y	230 (?)	8×10^{-7} mg.	1.5 days	β	—
↓ Uranium X	230	1.3×10^{-5} "	24.6 "	$\beta+\gamma$	—
↓ Ionium	230	39 mg (?)	2×10^5 yrs. (?)	α	3.00 "
↓ Radium	226	0.34 "	2000 yrs.	α	3.30 "

Radium, in its turn, continues to disintegrate into products, the quantities, life periods, and radiations of which are shown in Table II.

TABLE II (Rutherford, page 518)

RADIUM SERIES

Radium series	Atomic weight	Weight per gram of radium	Half-value period	Radiation	Range of α rays at 15° C.
Radium	226	1 gr.	2000 yrs.	α+slow β	3.30 cms
↓ Ra. Emanation	222	5.7×10^{-6} gr.	3.85 days	α	4.16 "
↓ Radium A	218	3.1×10^{-9} "	3.0 mins.	α	4.75 "
↓ Radium B	214	2.7×10^{-8} "	26.8 mins.	$\beta+\gamma$	—
↓ Radium C	214	2.0×10^{-8} "	19.5 mins.	$\alpha+\beta+\gamma$	6.57 "
↘ Ra. C^2	—	—	1.4 mins.	β	—
↓ Radium D	210	8.6×10^{-3} "	16.5 yrs.	slow β	—
↓ Radium E	210	7.1×10^{-5} "	5.0 days	$\beta+\gamma$	—
↓ Radium F	210	1.9×10^{-4} "	136 days	α	3.77"

The facts here tabulated, although beyond mental conception, are known with far greater certainty than many scientific facts often taken for granted.

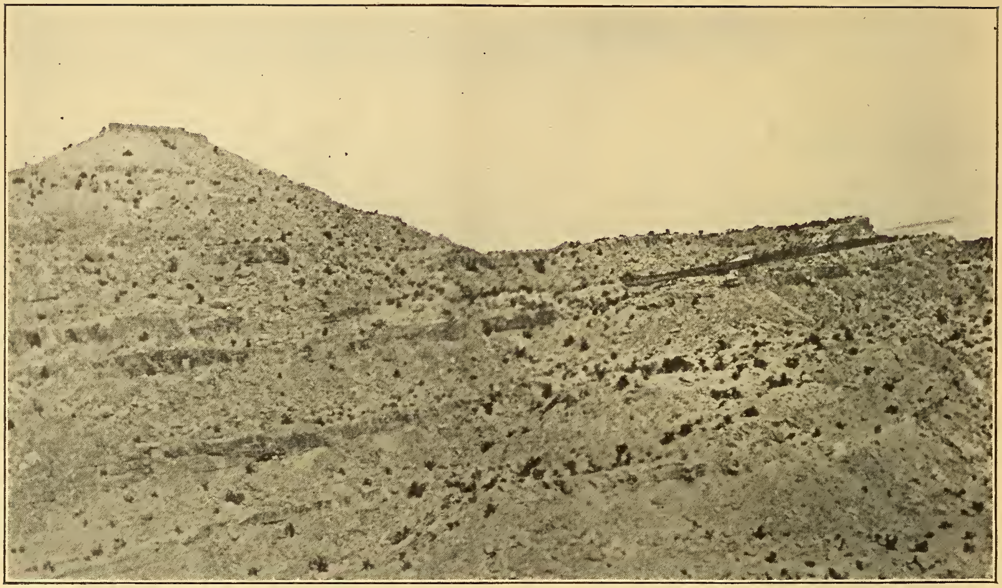
In most uranium minerals the amount of radium present is represented by one part of radium to three million parts of uranium. The half life of uranium, or the time within which one half of any given quantity of the element will disintegrate into other materials, is about

East Side of Parador Valley

five billion years; while ionium, the immediate parent of radium, has a half life of 200,000 years; and radium itself a half life of 2,000 years. Accordingly, it will be seen that, although the energy given off by these elements in ordinary periods of time may appear inexhaustible, it is not really so. Table II shows how radium is continually disintegrating and indicates that the material which we ordinarily speak of as radium is really a mixture of radium with the disintegration products enumerated in this paper. Many lectures would be needed to describe all the scientific aspects of the subject. A few of the more important facts only can be mentioned here.

Already some sixteen elements have been positively identified which result from the progressive breaking down of uranium and its decomposition products. One metric ton or 1 billion milligrams of uranium contains, when in equilibrium with its disintegration products, some 25,000 mgs. of ionium; $312\frac{1}{2}$ mgs. of radium; 2/1000ths of 1 mg. of emanation; and 7 millionths of a mg. of Radium C. As already stated, these radio-active elements, and others not here enumerated, have been identified and studied almost wholly through the unprecedented amount of spontaneous energy they evolve. This energy is so intense that it is possible to measure the amount evolved by one fifty-millionth of a mg. or one three-thousand-millionth (1/3,000,000,000) of a grain of radium and even a very much smaller amount can be detected. These figures, of course, are in themselves incomprehensible, but if a piece of radium as large as a grain of wheat were divided among the inhabitants of the earth it would be easy not only to determine whether each individual had his portion but also to measure the radium he possessed.

One gram of radium in equilibrium with its disintegration products gives off 133 calories of heat per hour; or, in other words, sufficient heat to raise in approximately three-quarters of an hour, its own weight of water from the melting to the boiling point. During the full life of the element it would accordingly yield 3,700,000,000 calories. Of this energy, nearly three-fourths is evolved by the decomposition of the first product of radium which is a gas of the helium



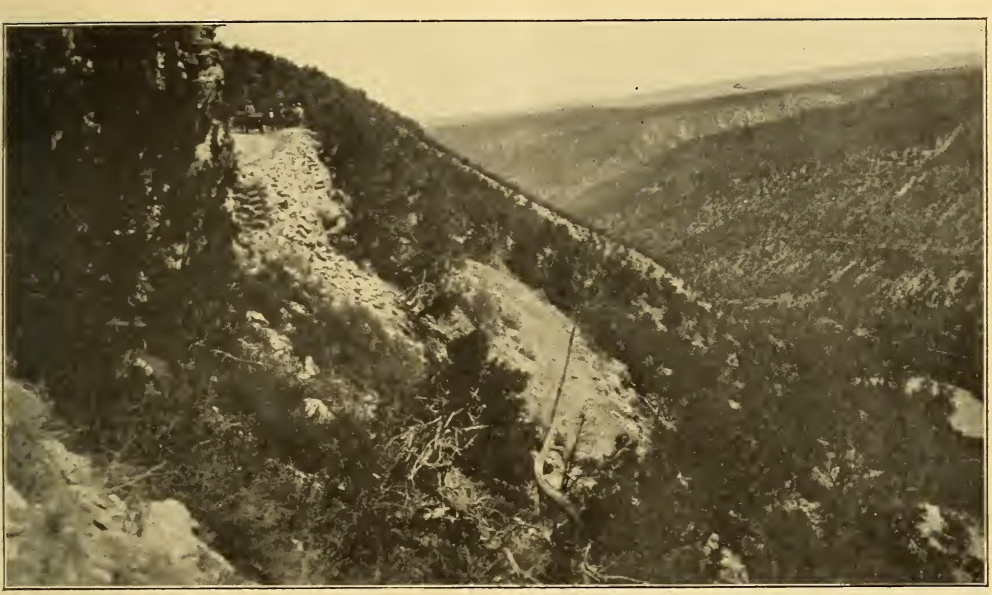
Utah Carnotite Country

argon group and is known as radium emanation, or niton.

It would require a half ton of pure radium to yield a single pint of this gas, but, if obtained, no material is known which would not melt instantly if used as a container.

The energy from these radio-active elements is manifest in three forms of radiation, known as the alpha, beta, and gamma rays. Radium itself gives off only alpha rays, but when, thirty days after separation from solutions containing it, the radium has reached a state of equilibrium with its dissociation products, the mixed material, which in commerce is known as radium, yields all three kinds of rays. I shall now consider these rays briefly.

The so-called alpha rays are simply positively charged atoms of helium thrown off with a velocity varying from some 8,000 to 12,000 miles per second. This is over two hundred times as fast as the swiftest flight of the next fastest material thing known in space, *i. e.*, a shooting star. On account of the mass of the helium atom and the rapidity of its flight, the alpha rays carry with them over 90 per cent. of the total energy evolved. They apparently pass through all other atoms and molecules that come within their path, but of the three rays given off by radium they are the least penetrating, being stopped by some 3 cm. of air or a comparatively thin film of any ponderable matter. They have only about 1/100 of the penetration of the beta rays and 1/1,000 to 1/10,000 of the penetration of the gamma rays. The study of these alpha rays has thrown much light on the constitution of the radio-active elements and on that of some of the other elements as well. By the loss of an alpha ray or helium atom, (atomic mass, four) the atom remaining is changed to another element having an atomic mass four units less than its parent and chemical properties which place it two groups to the left in the ordinary periodic scale. The alpha ray carries with it not only the helium atom, but also two charges of positive electricity, so that the valency of the resulting element is diminished by two. The energy of the alpha rays is so great that, by at least two distinct and separate methods, it has been possible to actually count



Gateway to Carnotite Country

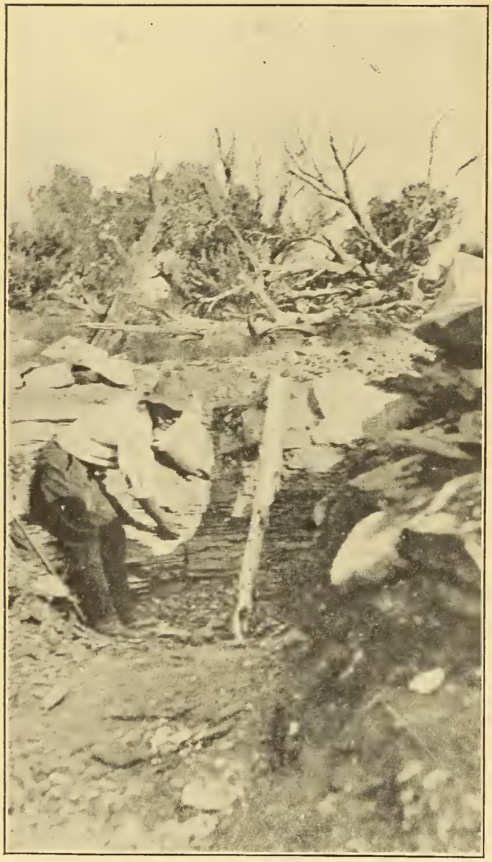
these positively charged helium atoms as they are expelled one by one from radium. So that it is known that a single mg. of radium (or approximately 1/10 the weight of the ordinary pin head) expels, every second, 136 million alpha particles. Indeed, the counting of atoms of more than one form of matter is now done with such precision that, as stated by Prof. R. A. Milliken (*Science*, Vol. 37, page 119), scientists can now count atoms as accurately as one can count the inhabitants of a large city. It is hard to conceive that a single milligram of radium can continue to give off these millions of atoms per second for many thousands of years without complete disintegration, but such is actually the case.

The beta rays are negatively charged particles of electricity or electrons. They have approximately 1/1800 of the mass of the hydrogen atom and the velocity of the different beta rays given off by the different disintegration products varies greatly. Their average velocity is from 40 to 80 per cent. of that of light (185,000 miles per second), but some go as fast as light. They have approximately one hundred times the penetrating power of the alpha ray but are stopped by a few millimeters of lead or by proportionately greater thicknesses of less dense material. These beta rays are analogous to the cathode rays, but have much greater velocity than the cathode rays themselves. The loss of a beta particle from an atom of any one of these elements does not sensibly affect the atomic weight of the new element formed, but does increase the valency of the element by 1, so that the new element produced by the loss of a single electron has chemical properties which place it in the periodic table one group to the right.

The gamma rays of radium are perhaps the most interesting of all, although they carry with them comparatively little energy. They have recently been definitely shown to be light vibrations, having a wave length almost infinitesimally small. To speak in comparative terms, they are probably light, having a wave length perhaps 1/100 of that of the X ray, which itself has a wave length about 1/10,000 of that of ultra violet light.

The gamma rays are especially interesting and important, for the reason that,

perhaps because of their great penetrating power, they are the chief effective therapeutic agent in the radium treatment of cancerous growths. The gamma rays are emitted almost entirely from the decomposition product of radium known as Radium C. When I show you by convincing lantern slides, as I shall in a few minutes, the results obtained in the treatment of cancer, it will be hard for



A Carnotite Discovery

you to realize that these results were produced by the gamma rays from less than 2/100,000 of a single mg. of this remarkable element, which, although never seen by human eye, exists beyond the possibility of doubt.

The radio-active elements are studied, their quantities determined, and effects measured, chiefly by means of an instrument known as the electroscope.

This brief summary, stated in language intended to be illustrative rather than scientific, may give you an idea of the element which has attracted so much attention. At present the European nations are competing for supplies of this element at prices that, because of scarcity of the material, are almost fabulous.

Radium was first produced from the pitchblende ores of Joachimstaal, Bohemia, but these have failed to yield radium enough for even European use. In fact the radium ores have become so valuable that the Austrian Government owns the deposits and has forbidden by law the exportation of this ore. Consequently, radium ores are being sought all over the civilized world, and wherever prospectors go. They have not been found in really large quantities in any locality. Besides the pitchblende from Austrian deposits, a few tons of pitchblende concentrates are now obtained each year from the old tin mines in Cornwall. Some autunite, a beautiful uranium phosphate, is produced from Portugal and from Australia. Carnotite, a complex vanadate of uranium, is known to exist in Ferghana, Russian Turkestan. It is being mined in Australia and treated by a plant in Sydney that has a present yield of some 150 mgs. of radium per month. It can, however, be definitely stated that no one of the foreign deposits compares in extent or richness with the carnotite ore fields of Colorado and Utah.

In 1912 the United States Bureau of Mines established a laboratory in Denver and sent experts into the field to study the rare metal problems of the West. One of the first things ascertained was that carnotite was being mined and shipped abroad from the Paradox Valley in Colorado and few persons realized why it was being exported. It is now well known that the ores mined and shipped from American deposits during the last three years have yielded much more than half of the total radium production to date. This last

View from Mouth of "Black Fox Mine," Bull Cañon, Colorado

year over three times as much radium was taken from American deposits as from all other sources combined. In spite of these facts there is today available to American hospitals less than $1\frac{1}{2}$ grams of radium element. German hospitals, on the other hand, are known to have acquired or contracted for 15 to 16 grams of radium bromide since June, 1913, to be paid for mainly by state and municipal appropriations.

During 1912, practically all of the ore mined in America was shipped abroad. In 1913 an American company with headquarters in Pittsburgh, Pa., began to produce and market radium, and to January 1, 1914, it had produced 1,350 mgs. of the element and had shipped to its plant a little less than one-half of the carnotite mined in this country last year. More than half of the probable 1914 output of this concern has already been contracted for abroad. These facts, and the great need of radium in American hospitals, has led to bills being introduced in Congress to give the government a preferential right in the purchase of ore mined on government land, and to provide for the extraction and purification of radium from the ores so purchased. Unfortunately, while these bills were being debated in committee hearings, practically every known public deposit of the material was staked either by prospectors or by corporations interested.

American carnotite is found chiefly in Montrose and San Miguel counties, Colorado, and in that part of Utah, northwest of these counties. The Utah deposits are at Green River, Table Mountain, Richardson, Fruita, Moab, and some sixteen miles southeast of Thompsons. The ores of these deposits are of lower grade than those of the Paradox Valley, but they are nearer to railroads and subject to lower transportation costs. The Green River deposits have apparently become regular producers. In Colorado, prospects have been opened at Coal Creek, fourteen miles north of Meeker, and at Skull Creek, sixty-five miles west of Meeker; but the richest of carnotite deposits in America and indeed the richest known radium bearing region in the world is that of the Paradox Valley, Colorado, which extends from Hydraulic on the north to the McIntyre District on the south.

In the Paradox region, the deposits seem to lie invariably just above the fine grained La Plata sandstone. This rock is usually exposed high on the sides of the canyons, some of which are excelled in extent and in natural beauty by only the Grand Canyon itself. In a few instances, as at Long Park and Club Ranch, the deposits are only a few feet under the surface, the higher formations having been eroded; but the stratum in which the carnotite occurs, when not entirely eroded, is deep below the surface of the mesa. Accordingly, prospecting is mainly carried on along the sides of the canyons; where vanadium and uranium stains are seen upon the rock, the prospector blasts his tunnel, in the hope of finding a pocket of the ore. The fact that the ore occurs in pockets renders prospecting uncertain, and there appears to be no present hope of insuring a successful search for pockets that are not exposed or do not happen to be near the surface. Although it is probable that many pockets of carnotite occur in the same geologic horizon, their discovery, except where the ore-bearing stratum has been exposed by erosion, appears at present to be an almost hopeless task. The eroded sides of the canyons have been prospected again and again, but new claims are still being opened and are being sold by the prospector to the large companies or operators who mine the ore. In such a sale the prospector and the purchaser both take a decided risk, for at present no method is used to determine the extent of the ore in the pocket other than the "prospector's hole."

There are two important ores of radium found in this country, carnotite and pitchblende, although carnotite is by far the most important, and more radium has already been produced from this ore than from all other ores put together. Carnotite is a lemon-yellow mineral and is usually found in pockets in sandstone. It may occur as light yellow specks, disseminated through the sandstone, or as yellow incrustations in cracks; or it may be more or less massive, associated with blue, black, or brown vanadium ores. Pitchblende, on the other hand, is a hard, blue-black ore that looks like magnetite, but is heavier. It is found in pockets and veins of igneous rocks. It is not nearly as widely distributed as carnotite. Either one of these ores may be easily identified and a rough estimate of its uranium content determined in a few minutes by means of the electroscope; or, if an electroscope is not at hand, the radio-activity may be proved through photographic methods. All that is necessary is to wrap in the dark a photographic plate in two or three thicknesses of black paper. On the paper, lay a piece of thin metal with sharp outlines such as a key or clock wheel, and just above this object suspend two or three ounces of the ore. Place the whole in a light-tight box for three or four days. If the plate is developed in the ordinary way, and the ore is appreciably radio-active, a sharply defined image of the key or other object will be found on the plate.

The foreign manufacturers have agents and buyers in America and most of the rich claims are now in the hands of three or four corporations, but so far as the hearings before Congress are concerned, they have worked together almost as a unit in an effort to defeat the proposed legislation. In spite of the humanitarian standpoint involved, this is perhaps not to be wondered at, when it is considered that the best authorities believe that the present cost of manufacturing radium is scarcely more than one-fourth of its selling price.

Most of the ore deposits are in a desert region and are many miles from the nearest railroad. In the Paradox Valley, which is by far the richest radium-bearing region of the world, the ores have to be hauled by wagons forty to seventy miles to the nearest railroad station and the ores from many claims have to be packed on burros some miles to the nearest point to which roads can be built. The cost of mining, and especially of transportation, is therefore an important factor in the marketing of carnotite.

The Green River, Utah, deposits have a distinct advantage over the Colorado

Entrance to "Yellow Bird Mine"

deposits in regard to freight rates, as they are nearer to the railroad, but as their ores do not average as high in uranium, this advantage is more apparent than real. The present costs of mining, sorting and sacking in the Paradox apparently vary from about $28 to $40 per ton. To this must be added $18 to $20 for the haul to Placerville, and, in most instances, an additional charge for burros from the mines to points that can be reached by wagon. The freight rate from Placerville to Hamburg, via Galveston, is $14.50 per ton, so that the average cost at present to the miner of laying down his ore at the European markets approximates $70 per ton. The selling price varies with the uranium content, but is by no means proportional thereto, since a premium is always paid for rich ores. Very recently, however, a decided improvement has taken place and for ore containing 2 per cent. uranium oxide, the price, delivered in Europe, is now about $2.50 per pound for the oxide, an allowance of about thirteen cents per pound being made for the content of vanadium oxide, so that the 2 per cent. ore delivered in Hamburg brings about $110 per ton. One and one-half per cent. ore is now salable, but unless this ore is taken from the dump so that the mining cost may be disregarded, it will scarcely bear even present transportation charges from the Paradox, although such ore probably will soon be shipped regularly from the Utah field.

A price of $110 at Hamburg for 2 per cent. ore leaves a good margin of profit to the miner, as mining profits go, but when one considers that this price represents only a little over one-fourth of the value of the radium content of the ore, and that from this fraction of the value the American miner has to meet the outlay represented by the investment, by mining costs, transportation and assay costs and by losses in transit, it seems scarcely just that nearly three-fourths of the value should go to foreign manufacturers of radium, especially if one remembers that radium can be produced much more readily from carnotite than from pitchblende. There are two ways of reducing this difference between the actual value of the ore and the price that the miner receives. One is for the producer to hold American ores for a higher

price, and the second is to manufacture radium under Government auspices.

One of the most important features of the whole problem is the saving of the present wastes. For every ton of high grade ore that is taken from the mine, at least four tons, and probably more, of low grade ore are left on the dump. Some of these dumps will be later worked for their radium, but in many of them the low grade ores have already been so mixed with gangue material that profitable separation is practically hopeless and in addition much fine ore has been blown away by the winds or washed away by the rainfall of the short rainy season. As a result twice as much radium is wasted as is being produced.

There is now some prospect that through the activities of the Bureau of Mines these low grade ores in future will be carefully stored and it is also probable that concentration plants will be soon in operation—thus preventing some of the losses. In any case, mechanical concentration is inefficient,—and distance from the railroad makes chemical concentration at present impossible. Mechanical concentration probably can, however, save at least one-half of the material now going to waste.

The price of radium is now approximately $120 per mg. of radium element in radium bromide of 60 per cent. purity. In bromide of 90 per cent. purity the price is as high as $180 per mg. and foreign governments have paid even much higher prices than this. A price of $120 per mg. does not mean that the material is bought in the elementary condition, but that the radium chloride and radium bromide, now on the market, are paid for on the basis of the metallic radium they contain. This price of $120 per mg. of element is equivalent to approximately $91,000 per gram of radium chloride or $70,000 per gram of anhydrous radium bromide. Whether these prices will rise, fall, or remain stationary cannot be predicted. The production of radium is sure to be larger and meso-thorium is coming on the market in increasing quantity. On the other hand, the supply of radium-bearing ores is limited and no large resources are in sight. The most favorable estimate made by any of the employees of the Bureau of Mines who have been through the American carnotite field is that the known deposits do not warrant the assumption that as much as 200 grams of radium element will ever be produced from that field.

Several radium institutes have been founded throughout the world for studying the application of radium to science and to disease. Some of these are public and some private. Prominent among them may be mentioned the Radium Institute of Austria, founded under a donation given by Dr. Kuppelweiser to the Academy of Science of Austria, which now has one of the largest supplies of pure radium salts used chiefly in scientific investigations. In Paris, a new radium institute under the direction of the Sorbonne has been built by this university near the Pantheon. In England, the London Radium Institute was founded by Sir Ernest Cassel and Viscount Iveah, who gave a large sum for its endowment. This institute is making a special study of the application of radium to disease.

In this country, the National Radium Institute has recently been founded by Dr. Howard A. Kelly of Baltimore and Dr. James Douglas of New York City, and I am fortunate in having been connected with the work of this institute since its inception. When it became known through the investigations of the United States Bureau of Mines, in the latter months of 1912, that valuable radium ores were being shipped abroad to be manufactured into radium and sold back into this country at prices entirely incommensurate with those paid for the ores themselves, it was deemed necessary to take prompt action to insure at least a portion of this radium being available to the people of the United States under such conditions as would prevent it from being altogether a rich man's remedy. The matter was called to the attention of Doctor Kelly and Doctor Douglas, both of whom were known to be deeply interested in radium for use in two hospitals with which they were

Cliff Mine, "Saucer Basin," showing dump containing many hundreds of tons of wasted ore

closely connected, and they immediately favored the formation of an institute to extract radium from American ores and to keep the radium in this country. It was agreed, if the ores could be procured, that the radium institute would be founded and the necessary funds furnished to work up the raw material. Through the active interest of the officials of the Crucible Steel Mining and Milling Company, sixteen claims containing carnotite, in Montrose County, Colorado, were leased on a royalty basis under an agreement providing for the return of the uranium and vanadium content of the ores to the owners of the claims, and the National Radium Institute was founded. As the Denver office of the Bureau of Mines had been carrying on laboratory experiments and field investigations with reference to uranium ores, and the Bureau had published a bulletin covering these investigations, the institute proposed a coöperative agreement, whereby the Bureau was offered an opportunity for studying the mining and concentration of the carnotite ores, and the most practical and least wasteful methods of obtaining uranium, radium, and vanadium therefrom. Under the agreement, the chemical management of the mines and mills is to be guided by the scientific staff of the Bureau of Mines. One hundred and twenty tons of high grade ore have already been procured; the mill has been built, and began to treat ore on March 18. It is believed that this agreement will assist the prospector and the miner, by providing a greater demand for his ore, and, by aiding to reduce the great wastes which now take place, will help the plant operator, by developing methods of treatment and by creating a larger demand for his products; and finally, will benefit the people by making available for use, in two American hospitals, at least four times as much radium as is now in the country. The radium produced will be used without profit to the donors, in the treatment of cancer and other malignant diseases. As you all know, the press of the country has been in an excited state for some two or three months over the application of radium to the cure of cancer. Much has been printed that had no justification in fact, but that the subject is of the utmost

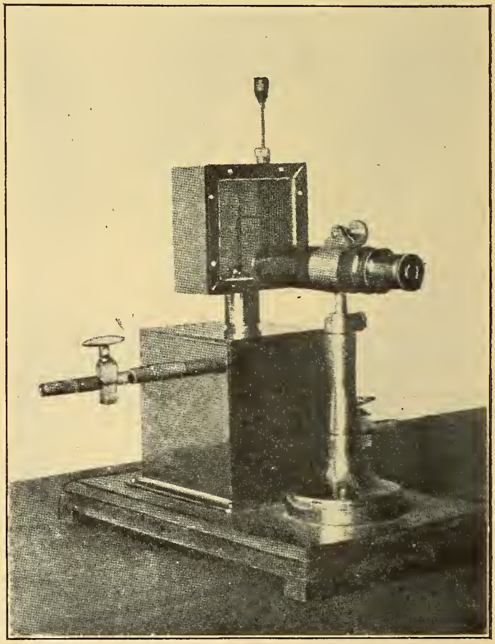
importance can be easily demonstrated. Reporters in many cases have claimed for radium much more than was even hoped by those most familiar with the subject; while, on the other hand, many eminent physicians have expressed disbelief in the efficiency of radium without having any personal knowledge whatever of its application. There are today, in this country, only two or three centers where sufficient radium has been experimented with to entitle the experimenters to express an opinion from personal experience as to its efficacy.

At the hearings in Washington before committees of Congress, Dr. Robert Abbe of New York, who had some 350 mgs. of radium bromide, reported cancer cures of eleven years' standing and that Dr. Howard A. Kelly and his associate, Dr. Curtis F. Burnam, who had been working for some years with radium and had approximately 1 gram of radium bromide, reported cancer cures of five years' standing, without recurrence, including cures of all forms of cancer—epithelioma, sarcoma, and carcinoma.

In spite of the fact that statistics have shown that there are 200,000 cancer patients in the United States, with an average of 75,000 deaths per year; that the chief of the Hygienic Laboratory in Washington stated before the Senate Committee that he had been convinced against his will of the efficacy of radium treatment in many cases of cancer; that the United States is producing some three times as much radium ore as all the rest of the world put together; that the ore to be conserved is on Government land; that Germany and France are not only purchasing American ores but are taking by far the larger part of the output of the one American plant producing radium; and that immediate action was necessary to insure any portion of the material being conserved to our people, the bills have not yet been acted upon in either the House or Senate.

In this connection the following quotation from a recent editorial in the *Washington Times* may prove of interest:

"Cancer is a poor man's disease. . . . Radium now selling at $120,000 per gram is a rich man's remedy. Hospitals which are charitable, and philanthropic institutions cannot afford to pay the price that is demanded for radium. . . . The deaths from cancer in the United States reach 75,000 each year or 200 every day. The contention of the Federal Government is that if a preferential right is given to it to purchase carnotite ores it will develop the entire field and smash the present monopoly, which is charging prohibitive prices for radium. The plea of those opposed is that the miner must be protected. That plea involved, in 1913, 150 miners and prospectors and is used as an argument against 200 deaths a day from cancer. In the sixty-five days of discussion there have been 13,000 victims of cancer and each succeeding day of delay there are 200 deaths, some of which might have been avoided if the Government had an opportunity to place radium in the different hospitals of the country.



Electroscope for determining the Uranium content of an ore

"Colorado has the greatest known deposits of radium bearing ores and these

ores are all on the public domain. Colorado has had the most wonderful humanitarian opportunity ever offered a state, and yet the selfish interests of a few people have so far blocked any attempt upon the part of the Federal Government, on its own property, to obtain for the victims of cancer a remedy which has been wonderful in its results."

Whether or not radium is invaluable in the treatment of cancer, and whether there is accordingly some justification for the editorial quoted, must be determined by the testimony at hand.*

Dr. Howard A. Kelly, Dr. Curtis F. Burnam, and Dr. Robert Abbe gave testimony before the Mines and Mining Committee of the House of Representatives of many cancer cures accomplished in the hospitals under their supervision. There is no higher authority in the country than these doctors. Their conclusions have been criticised chiefly by those who have read the much exaggerated newspaper articles as to their statements. So far as I have been able to determine, those who have visited their hospitals and seen the results of their treatment are convinced of the efficacy of radium in cancer therapy; and having carefully investigated the results of actual practice have been themselves convinced of its value. Criticisms from other physicians have been printed mainly in the public press, but, so far as I can ascertain, no one of these physicians has had the slightest experience in the use of a sufficient quantity of radium to entitle him to render judgment and they have frequently come to their conclusions from the statements of physicians who had only a few milligrams of radium or because certain cases of cancer, in prominent individuals that were in the last stages of the disease, were not cured. To judge from such data is much like condemning the statements of those who smelt iron in blast furnaces because blacksmiths cannot reduce ores commercially in their forges.

My own observation has led me to agree absolutely with the statements of Dr. John F. Anderson, director of the Hygienic Laboratory of the United States Public Health Service, as given on page 161 of the Hearings before the Committee on Mines and Mining, U. S. Senate, February 10–23, 1914.

"I have been forced to the conclusion, I may say, somewhat unwillingly, that the use of radium has a very important place in the treatment of malignant tumors. The greatest use at the present time seems to be in the treatment of certain forms of cancer, technically known as epithelioma, and in the treatment of another form of malignant tumor, technically known as sarcoma. These growths are external and can be readily gotten at and the radium can be readily applied to them. I think some of the discredit, if I may so term it, that the use of radium has been given, has been due to the fact that attempts have been made, first, with too small amounts to treat these various growths; and second, attempt to treat cases that are practically beyond any hope.†

"I think the profession, as a whole, has no way of judging the value of this other than by statements made by persons who have a sufficient amount of radium to work with. Up to this time, in this country, there are only two doctors who have had a sufficient amount of radium to work with, and therefore the only two whose results can be considered as showing what radium can do. They are Doctors Howard A. Kelly and Robert Abbe."

No person can have been in touch with some of the wonderful cures that have been accomplished through the use of sufficient quantities of radium in the hands of experts and not be convinced that we have at last obtained the greatest weapon so far discovered with which to combat cancerous growths.

*At this point, several lantern slides showing cancer cures were given but cannot be reproduced here.

†At this point Doctor Anderson presented several photographs of cancer cases which are reproduced in the record.

Jean Henri Fabre

Permission of the Century Company

JEAN HENRI FABRE

THE STORY OF THE GREAT NATURALIST'S STRUGGLES TO PURSUE HIS CHERISHED CALLING — HOW PUBLIC RECOGNITION FINALLY CAME TO HIM LATE IN LIFE

BY CAROLINE CHASE BIGELOW

Jean Henri Fabre was born at Saint Léons, in the Haut Rouerque, on December 22, 1823. From his autobiographical notes, we learn that his parentage was indeed poor and humble. At an early age, to make one less mouth to feed in the impoverished family, he was sent to Malaval to pass the early years of childhood in his paternal grandmother's care. Here he remained till he was seven, surrounded by the humblest people, uncultivated, unimaginative, yet showing, even in his childish fancies, the love of nature and the observing powers of the naturalist, which were to characterize his later career. He then was placed at a School in St. Léons (1830) kept by his godfather. Next, his parents placed him, when eleven years old, at the Collège de Rodez, (1833–35), where his services as chapel boy defrayed the cost of his tuition. His childish love and interest in nature grew stronger each day, and he became more and more eager to investigate her secrets.

Financial misfortunes followed, and the Fabres moved to Toulouse (1839). Henri studied gratuitously at the seminary of the Esquille, but, in a year, the family were moving again, this time to Montpellier. Here misfortunes seemed to descend with a dreary finality, and the future naturalist was obliged to drop his studies and earn his living with the sweat of his brow, even working on the road with a gang of day laborers. During this dark period his passion for learning never waned and his love of nature offered him continual comfort. Buoyed by this courage, even amidst all sorts of privations, he ventured to enter a competitive examination for a bursary, or position of pupil with some teaching duties to compensate for instruction received. Fortunately he was successful, and was accepted as assistant in the École Normale Primaire at Avignon. Here he was assured meat and drink, and also some time to give to his beloved study of nature. At one time he was spending so much time in this study, that he was reprimanded by his superiors and restored to favor only after such diligent work otherwise that he was nearly a year ahead of his fellow pupils. He was interested in other studies besides natural history, however, and realizing that his livelihood as a teacher could not be gained by the study of insects alone, he applied himself to mathematics and chemistry (though with no laboratory equipment), and was rewarded at the age of 19 by a superior diploma.

The College of Carpentras offered Fabre the position of primary teacher in 1842 on the mere pittance of about $150.00 a year. In spite of discouraging surroundings, however, Fabre's ambition kept him up with the hope that success here would mean a better position elsewhere. He taught his beloved sciences, and especially in chemistry, where he learned almost step by step with his pupils, did he have marked success. His spare moments were devoted to his natural history and he started a collection of specimens, insects, ferns, plants, rocks, in his little museum to be studied carefully as opportunity permitted. Two years after coming to Carpentras, his first marriage took place. He also prepared himself for further examinations, receiving from Montpellier two baccalaureates, and the license to teach mathematics and physical sciences. In possession of these various degrees, stamping him as a man of learning, Fabre hoped for a new position where he might have more

salary or devote all his time to natural sciences. He waited long, but at last he was offered the chair of physics at Ajaccio at a salary of $360.00, and he hastened at once to Corsica (1848).

Fabre's stay in Corsica extended over about five years, with one visit to the mainland because of illness. He intended to devote these years, apart from the hours demanded for his teaching, to the study of mathematics; but the wonderful beauty of the island, the luxuriant flora, the manifold treasures of the sea, captivated the poetic naturalist and, instead, he spent much of his leisure collecting and studying the thousand specimens which were ever before him. Here, also, he made two friendships which materially encouraged his studies along these lines. Requien, a then famous botanist of Avignon, visited the island, as did Moquin-Tandon, professor from Toulouse. Requien was an enthusiastic collector, with a wonderful memory for the masses of things observed; Moquin-Tandon, who was, in a way, the successor of Requien in the study of Corsican vegetation, went a step farther, laying stress on beauty of expression, and on the philosophy of life as expressed in the creations of nature. Such influence fell on fertile soil in the mind of the young Ajaccio professor. To quote Fabre's own words, never again should he sit at such an intellectual feast as that. "Leave your mathematics," said Moquin-Tandon to him, "no one will take the least interest in your formulae. Go to the beast, the plant, and if, as I believe, the fever burns in your brain, you will find men to listen to you."

From Corsica, Fabre was called to teach in the Lycée at Avignon, 1853. Encouraged by this new appointment, he allowed himself to hope he might yet teach in the higher grades, and, in preparation for this, he obtained a third diploma, this time for the teaching of natural sciences (1854). The twenty years of service at Avignon which were now to come, brought him, unfortunately, no higher academic ranks, and when he finally quitted the work of teaching he stood no higher than when he was at Corsica. These years, however, were ones of great activity and were those which definitely worked out the course of the naturalist. At the end of the period he was thoroughly started on the line of work in which he excelled.

Meanwhile his salary had fallen to but $320.00 a year, while his family had increased, so that each day there were seven to be provided for. Hence Fabre was obliged to take private pupils or any other work which presented itself, so great was the need for more income. Yet in spite of these cares, he was at this time engaged in an important piece of work. Soon after his arrival at Avignon, a volume of León Dufour had come under his observation, and suggested to him that minute, careful, personal experiment and observation was a field in which he might realize the heights of his desires. Réamur and the two Hubers had undertaken similiar work. As the first fruits of this inspiration, he published, in 1855, in *The Annales des Sciences Naturelles*, "The Memoirs of the Great Cerceris" (a wasp). The same year he presented himself for a doctorate in Paris, trusting that such a degree would eventually reward him with university connections. The thesis in zoölogy dealt with the Myriapoda, that in botany, with the singularities of a strange family of orchids; neither work contained any strikingly original material.

Two years after the paper on the wasp, Fabre published (1857) a second masterpiece, his observations on the beetle. The Institute had recognized his ability by granting him a prize in experimental physiology, 1856. For a time, his financial status, too, improved, as the Lycée appointed him drawing master (1857), and the city made him curator of the Museum and, soon, museum lecturer, thereby adding about $240.00 per annum to his slender income. In spite of these additional salaries, Fabre was continually confronted with the problem of securing sufficient income to meet the demands of life, and at the same time of giving himself leisure for study along his special lines. In his desperate searches for a solution to this problem, it occurred

to him that the growth of madder, plentiful in the region, might have great commercial advantages as a dye product. He threw himself into this work, and spent some years devising means of manufacturing dyes, but when success seemed almost on the horizon, the synthetic manufacture of madder dyes was taken up by others, with greater commercial values. All Fabre's efforts in these lines served but to give a few useful points to those who were to reap pecuniary results in the field where he had aspired to be first.

The hopes of a comfortable future, with a fixed income from this source, being dashed, Fabre began to add a penny now and then to his earnings by writing text-books, although his duties at the school were often so laborious, that he had scant time for other activities. To this period, belongs the acquaintance of two men who are well known enough to merit a word of mention. In 1865 Pasteur visited Fabre, having been referred to him as an authority in entomology. The hauteur of Pasteur towards the teacher at Avignon seems rather unwarranted and the visit did nothing to encourage a friendship between two men who might have had much in common. Far different was the attitude of John Stuart Mill, whom Fabre met at the Requien Museum. The two men met on the common ground of love for natural history and formed a friendship which, in one instance surely, was of the greatest value to Fabre.

Fabre now undertook, along with his municipal lectures, a series of free conferences in the ancient Abbey of Saint Martial. The burden of these courses was that many subjects, hitherto never proposed, might be taught to both young boys and young girls alike, and that natural history was a book which all might read and which had a fascination totally hidden by the tedious methods of university teaching. These wonderful discourses were, however, to aid in the undoing of the great leader, for the devout churchman and the pedant alike cried out against such truths, such heresy in presenting science to the young, such a position for one so humble to take. His colleagues from the Lycée failed to support him, and his dear friend Duruy, high in Paris educational circles, had himself fallen, because of clerical opposition. Harassed by this petty criticism, the end of his endurance was reached when he was denounced from the pulpit as a dangerous man. Then, at this moment, his landlady became, as it were, a tool of his enemies, and told him he must quit his dwelling at once. The poor man had absolutely no money to move to a new house, and not a friend at Avignon from whom he might ask help. Even the small income from his text-books had fallen away because of the war. At this crisis he turned to his friend, Mill, and waited not long for a reply. Mill lent him gladly a generous sum, and with this, Fabre severed his connection with the Lycée, and shook the hateful dust of Avignon from his feet. This was in 1871, and he established himself at Orange.

We now enter upon the last division of Fabre's life, the time devoted to science apart from any academic connection, and we may further divide this time into two periods: the life at Orange and the years at Sérignan, a suburb of Orange. Fabre lived at Orange about six or seven years, and to meet the demands of support for his family, he devoted himself almost unceasingly to the writing of text-books while there. The old text-books had been dry, unadorned information; now, to quote Legros, "What a contrast and a deliverance in these little books of Fabre's, so clear, so luminous, so simple, which for the first time spoke to the heart and the understanding; for work which one does not understand disgusts one." Such charm, all the same, did not always attract the public, and the income of the scientist was often far too small to supply his needs. Meanwhile he was also working on the book which had been for twenty-five years his desire to publish, and in 1878 appeared a collection of studies under the title of the first volume of the Souvenires Entomologiques. The days at Orange were also marked by three events which greatly saddened the harassed Fabre: his good friend, Mill, passed away, his oldest son, too, died, and he was

suddenly dismissed from the post of curator at the museum, the tender care of whose collections had been a great joy and comfort. (1873.)

In 1878, Fabre removed to Sérignan where he was able, primarily from the income of his little text-books, to purchase his home, dilapidated though that home was indeed. Henceforth he would be saved the pain of an unpoetic landlord, such as the one at Orange, who ruthlessly trimmed the beautiful plane trees in front of the cottage. For a period, at least, his books brought him in enough to exist in the simplest way, and to indulge himself in the cultivation of his little "terrain" as pleased his fancy, particularly the fostering of insect life. Not long after the removal to this scene of comparative comfort, sorrow came to Fabre again, with the death of his wife. Two years taught him the difficulties and loneliness of life alone, so he remarried, choosing a young and capable woman for his second wife. Three children were born of this union. Henceforth the life of Fabre may be outlined briefly, his attention given to his cherished studies, his life one of retirement, his home circle congenial and interested in his pursuits. While his text-books sold, the royalties on them were sufficient to keep the family, but when, after ten years of popularity, the sale fell off, poverty again stared Fabre in the face. The scientific reputation had come among biological professors, and within learned societies, the Institute had made him a corresponding member in 1887. Such people as Rostand and Maeterlinck were reading his work with due appreciation, but such fame does not provide meat and drink. By 1894, he was sore pressed for funds, and for some time the sole assured income was $600.00 given him by the Institute as the Geguer Prize. In 1899 he received the Petit d'Ormoy prize of $2000.00 from the Institute. In 1908 the stress was so great he endeavored to sell the collection of beautiful drawings he had made in life size of all the fungi of Provence. He consulted the poet Mistral on the disposition of this most treasured possession. The poet, touched by such pitiful circumstances, exerted himself actively in Fabre's behalf and finally succeeded in acquiring from the government a small pension of $300.00 per year for the aged man. It was then that his pupils, and a few others who knew him for what he really was, decided to celebrate his jubilee, hoping to attract a little public attention to his wonderful work. The celebration was on April 3, 1910: open house was kept at the modest dwelling, the garden, the Harmas so charmingly described in an essay, was opened to all, and visited by many; a banquet was held, and greetings from a host of famous men received. A golden plaque was made and presented to the poet scientist. Thus at last twilight was shed on the end of a beautiful day, and the aged scientist, though feeble, is now sought by many, some, in truth, inspired by curiosity, but others earnestly desiring to pay homage before it is too late, to this remarkable figure. Fabre feels he has not lived in vain, and that he has aided in opening the doors of the beauties of nature to many.

Now that Fabre has become a famous person, people are reading his books, criticizing his theories, judging his style. In the first field there is material in abundance, for we find fully eighty text-books, ten volumes of the Souveniers Entomologiques, and, of these, numerous translations. Various essays dealing with the same subject have been grouped together by translators and published under such titles as "The Life of the Fly," "The Life of the Spider," "Social Life in the Insect World." His power of accurate observation is very great and, as a scientist, he has been considered by some as second only to Réamur. His philosophical position was a distinct refusal to recognize evolution as a legitimate idea. The problems of instinct to which Bergson has called attention were opened up by Fabre, but he is considered by some too rapid in making deductions from his observations. John Henry Comstock says, "Beyond some descriptive criticism of the theory that instinct is inherited habit, modified by struggle for existence through countless generations, there is little in his work which helps us to solve

the problem of the essential nature of instinct. He has accumulated the bricks but has not erected the building."

Whatever may be the criticisms of other scientists of the theories Fabre lays down, they, and all the world else, are in accord in praise for the language and the style in which these ideas are conveyed to us. Maeterlinck calls him the Insect's Homer; Rostand affirms "he thinks like a philosopher and writes like a poet"; Bergson draws largely on his ideas and illustrations of insect life to make his own philosophy attractive. Fabre is untechnical in word, full of imagination; he portrays the living insect as it really is, clouded in a veil of poetry and romantic charm. He feels a personal friendliness for the little things he describes with such purity and grace of expression. He has taken the science of Nature from the hands of the mere observer and reasoner, and glorified it in the soul of the Poet.

References: *Review of Reviews*, May, 1913; *Outlook*, February 15, 1913; *Literary Digest*, October 18, 1913, Article by J. H. Comstock; Legros: Fabre the Poet; J. H. Fabre: Life of the Fly (Translated).

GOOD SOIL FOR COLON BACILLI

Charles Leon Cowles, a student in the Department of Biology and Public Health, at the Massachusetts Institute of Technology, has been investigating means for detecting the presence of bacillus coli in water. The position with regard to the identification of the bacilli is that they all look much alike and, to tell the difference between them, it is necessary to apply some other tests. Stains, resistance to acids and the ability to produce gas are among the methods of determining the species. Another way is to find foods or soils in which some particular species will grow. Of this kind of test, the mixing of lactose bile, obtained generally from the organs of oxen, has been a means of distinguishing between the B. coli and others, the medium being favorable to the growth of this particular bacillus.

The B. coli is an intestinal organism of man and its presence in water may be termed the red flag for typhoid and other diseases, and like the innocuous red flag at the railway crossing is a warning of a great danger. It is important, therefore, to gain some quick and reasonably accurate means of determining the presence of B. coli in domestic water supplies. The ordinary test with lactose bile media is not considered very delicate, in fact some authorities have pronounced it only twenty per cent. efficient.

What Mr. Cowles has done is to add one to two per cent. of bicarbonate of soda to the medium with the result that the B. coli grows rapidly and other forms slowly, besides which the soda will prevent the growth of moulds and spreaders, the latter quick-growing things that come perhaps from the atmosphere and cover and obscure the plate. The whole story, which already bears useful results, is but a report of progress, and is suggestive of the untouched fields for investigation that are here waiting for the biologist.

AERONAUTICAL INDUSTRY IN FRANCE

To show the magnitude of the aëronautical industry in France, the following information for the year 1913 has been compiled by the "Aero Club de France":

Spherical Balloons—		
Ascensions	837	
Passengers carried	2,290	
Hours duration aloft	4,640	
Pilot certificates granted	87	
Dirigibles		
Ships built	7	
Total power	2400	
Voyages	165	
Distance	15800 Km	
Hours duration aloft	345	
Passengers carried	1029	
Pilot certificates granted	29	
Aëroplanes—		
	1913	1912
Aeroplanes built	1148	1428
Sea planes built	146	—
Distance covered, km	13040000	5000000
Hours aloft	133800	39000
Cross country flights	23600	9100
Passengers carried	47900	12200
Pilot certificates granted	384	489
Aëroplane Motors		
Total power mounted in French aëroplanes	89,000	
Total power manufactured and sold	228,836	

J. C. H.

ADAPTATIONS OF CROPS TO SOIL

ENORMOUS RETURNS FROM EFFICIENT FARMING BASED IN A LARGE DEGREE ON PHYSICAL AND CHEMICAL RELATION OF SOIL TO CROPS

BY GEORGE E. STONE

The greatest advance in knowledge concerning the adaptation of crops to soils has been achieved through practice and experience rather than by means of field and laboratory studies of the soil. There are many conditions aside from the surface texture which play a part in this adaptation, such as the nature of the substratum, depth of water table, etc.; and some insight into the subject may also be had by studying the distribution of plants, as given in any flora. Of course New England has been settled for some generations and deforestation and agricultural pursuits have been carried on extensively so that we find many changes in our soils and consequent modification of the flora. Some of the many factors determining the distribution of plants are complex and difficult to eliminate from other factors, and at present not enough is known about them to determine their real significance.

On soils which only a half century ago supported certain types of vegetation we now find an entirely different flora owing to changes in the nature of the soil; lack of humus contributing largely to this modification. Some plants, such as the Canada thistle, were more common forty years ago in Massachusetts than at present, while some other plants which have grown here for some time under cultivation have recently escaped and become pests. It would naturally be supposed that this is due to a change in the environment, soil conditions or source of seed. But whether there is in plants as in races of men, a tendency to aggressiveness which, usually lying dormant, sometimes unaccountably breaks out, we will not venture to say; still there is some evidence to support such a theory.

Some plants are confined to bogs, some to sandy soils, and others to heavy, compact soils, and many are adapted to a great variety of conditions. Others are limited to salt marshes, and still others to territory within a few miles of the seacoast. Elevation, humus and soil moisture play an important rôle in plant distribution, and some plants are restricted by what is termed "seed habit," the seeds of some species retaining their germinating capacity for some time and others for only a few weeks or even days. For instance, the seeds of the willow, poplar, alder and other species native to wet locations remain viable only a few days or weeks, while others will do so for ten to twenty-five or more years. Seeds with a limited term of viability must therefore find suitable conditions for germination during this time, while the others can afford to await their opportunity.

Most garden seeds require a minimum of 2 to 3 per cent. of soil moisture to germinate at all, and for the best germination a higher percentage is required; therefore during dry seasons the seeds of some crops fail to catch. Purslane and pigweed seed, however, will germinate with a very small amount of soil moisture and flourish when more desirable plants will not.

The percentage of air in soils plays its part in plant adaptation, as do also the chemical constituents and biological characters. The soil texture or mechanical properties, which are inseparably connected with the air and moisture of the soil, together with the capillarity, etc., are also very important factors in plant distribution as well as crop production. It should be stated, however, that the specific effect on plant distribution of any one of the factors mentioned is not

Figure 1

known; still a great deal is known concerning the effects of chemical constituents on plants, much more study having been given to this subject. Soil differs materially in its chemical contents, and the configuration of the plant is greatly modified by the different types. Even in so small a territory as Massachusetts there are characteristic variations in the soil which are of sufficient importance to justify specialization in farming. In general, the finer particles of clay, silts, etc., increase from the seacoast to the western boundaries of the state, and the coarser particles,—sand, etc., predominate near the coast.

The river valleys furnish typical soils adapted to the growth of special crops, the meteorological conditions of these localities also emphasizing the individual character of the crops. The coarse and more friable soils of the coast are light and porous and are used largely for such market garden crops as lettuce, cucumbers, tomatoes, radishes, etc. This soil, characteristic of Belmont, Arlington and other towns about Boston, is especially adapted to head lettuce, which is grown more skillfully and successfully in that region than anywhere else. The texture of such a soil is shown in figure 1. It is characterized by a predominance of the coarser particles and a relatively small amount of the finer materials such as silts and clay. A compact soil is shown in figure 2. Except in some few localities

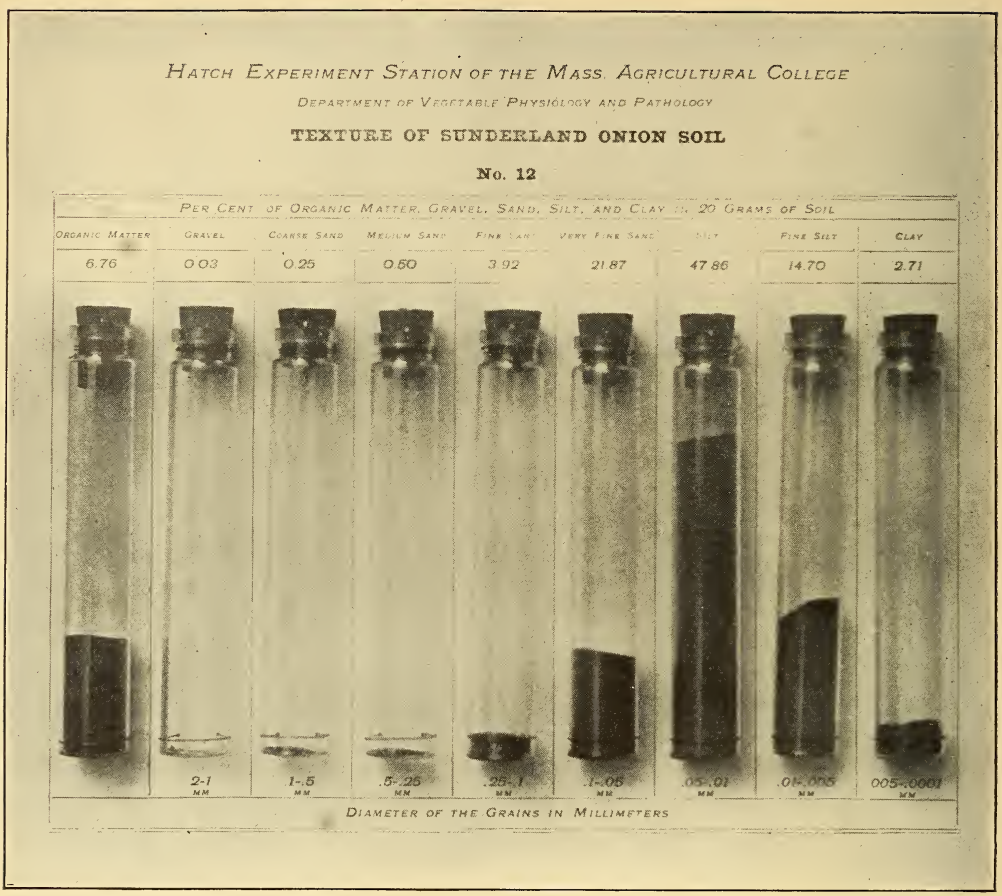


Figure 2

the interior soils are not nearly so well adapted to head lettuce, and for this reason the crop is not grown to any extent outside of Boston. In all its stages head lettuce requires a loose textured soil for perfect development. These soils are manured heavily year after year, and in the greenhouse are never changed; and the large amount of organic matter furnished by the decomposed horse manure renders the soil even better adapted to this particular crop.

The soils in the Connecticut valley differ from other Massachusetts soils in the high percentage of fine sand and silt contained; the fine sand predominating in some, and in others the silt. These soils have long been devoted to the growing of tobacco, onions and cucumbers, and to some extent, melons. While similar in texture, variations occur even in these valley soils which have a marked influence on certain crops. Tobacco in the Connecticut valley, except the tent grown, varies in price from 10c. to 30c. a pound, and the value of the crop is closely related to the texture of the soil, which therefore determines the quality of the crop to a great extent. This is also true to a less degree of onions, of which thousands of bushels are grown in the valley each year. Certain types of soil in the Connecticut valley,—*e.g.*, the warm, sandy textured soils, are unusually well adapted to melon culture, the crop growing more vigorously here than else-

where with less infection from blights, etc.

While asparagus is grown largely in the Cape region, in very dry, sandy soils with little water retaining capacity, it is not especially adapted to these conditions. The finer textured soils of the Connecticut valley are much superior for asparagus, which sometimes yields at the rate of $1,000 per acre in this locality. Besides, in light, sandy soils this crop suffers much more severely from rust than in the finer textured soils.

Roses are grown to quite an extent under glass in Massachusetts, and like tobacco and lettuce, are quite susceptible to the type of soil. This plant requires a very heavy soil, one of the best types being found in the Connecticut valley. A good rose soil should have a basis of about 80 per cent. of fine particles (very fine sand, silts and clay). Some of the best American Beauty soils are found in Pennsylvania, and contain 10 to 12 per cent. of clay and about 40 per cent. of silts. Such soils are not abundant in Massachusetts, although similar types are occasionally found.

There are other crops having a wider range of adaptability which will thrive fairly well on a great variety of soils, but the configuration of the plants will be affected. For instance, the apple can be grown successfully in various parts of Massachusetts, but a too dry or too wet soil should never be selected for it. It grows more luxuriantly in the fine textured soil of the Connecticut valley than elsewhere in our state, but has a tendency to run to wood and foliage; and the quality of the fruit, keeping qualities, etc., are not always so good as of those grown on higher elevations where the soil texture also differs.

The pear tree, on the other hand, will grow anywhere in the state, although in the Connecticut valley the quality of the fruit is inferior and the tree is more susceptible to fireblight and other diseases.

What are known as "drumlins" or clay hills, which are scattered throughout our state, are especially good for pastures, and the growth of hay, timothy, corn, potatoes and other crops; although their natural growth is chestnut. When Massachusetts was producing most of its own agricultural products these hills had the reputation of being the best farming land, and they were used extensively by the Indians and early settlers for farming purposes. As water is always found a few feet below the surface they suffer very little from drought.

The pronounced effects of soil texture, etc., on plant variations may be seen in the growth of our native trees. Of all native species the pine is best adapted to Massachusetts conditions. It will grow in very dry and in very wet soils, and if unmolested would cover the whole state in less than a century. The elm thrives best in certain types of river valley soils, where it produces large, thick, deep-colored leaves and attains a symmetrical growth. Elms also live longer in such a soil.

What is true of the elm is also true of the rock maple, which reaches a high degree of perfection in the Connecticut valley and lives to a great age. Soil or climatic conditions also produce many other variations in the growth of our native trees such as marked modification of branching habit, etc. The distribution of the smaller plants likewise offers many examples of adaptation which cannot be considered here.

Massachusetts has been long enough under cultivation and the crops grown of great enough variety to give one a fair idea of the soils and their general adaptability to crops. But factors such as pathogenic organisms and soil acidity are occasionally found interfering with crop production in certain soils. Massachusetts is naturally a timber state, but notwithstanding the relatively small amount of arable land the market and prices for produce are excellent.

The vast areas of fertile soil in the West when planted to cereals return about $20 per acre, while our market garden soils return from $500 to $2500 per acre. One square rod of greenhouse lettuce gives larger returns than one acre of wheat, and sometimes as much as two acres. A crop of tomatoes fetching $9,000 has been taken from less than three-quarters

of an acre of glass within five miles of Boston, and one-tenth of an acre of greenhouse cucumbers in one case returned $3,500, which is at the rate of $35,000 per acre. Other instances might be given of the enormous returns from intensive agriculture,—in reality only another term for unusually efficient farming. These returns are possible because the greenhouse grower is able largely to manufacture his environment, and to prepare his soil as he wants it; thus adapting his soil to the crop instead of the crop to the soil. When this intensive farming is in wider use the United States will be able to support many more millions of people than at present.

CONTRIBUTORS TO SCIENCE CONSPECTUS

The authors of the principal articles in the last volume of Science Conspectus are as follows: (This does not include articles by the staff.)

Prof. Charles T. Brues, assistant professor of economic entomology, Harvard University; Harrison G. Dyar, Ph.D., custodian of lepidoptera, United States National Museum, Washington, D. C.; Prof. S. P. Ferguson, professor of meteorology, University of Nevada; Woods Hutchinson, M.D., New York City; Prof. Percival Lowell, non-resident professor of astronomy, Massachusetts Institute of Technology, director of the Lowell Observatory, Flagstaff, Ariz.; John F. Norton, Ph.D., instructor in sanitary chemistry, Massachusetts Institute of Technology; Prof. Arthur A. Noyes, professor of theoretical chemistry, director of the Research Laboratory of Physical Chemistry, Massachusetts Institute of Technology; Prof. Earle B. Phelps, S.B., professor of sanitary engineering in the United States Hygienic Laboratory, Washington, D. C.; John Ritchie, Jr., former health commissioner of Boston, chief of news service of the Massachusetts Institute of Technology; George W. Rolfe, instructor in sugar analysis, Massachusetts Institute of Technology; Franz Schneider, S.M., Department of Surveys and Exhibits, Russell Sage Foundation, New York City; Prof. Hervey W. Shimer, Ph.D., associate professor of paleontology, Massachusetts Institute of Technology; Prof. Percy G. Stiles, Ph.D., assistant professor of physiology, Simmons College, Boston; Prof. H. P. Talbot, Ph.D., professor of inorganic chemistry, in charge of the Department of Chemistry and Chemical Engineering, Massachusetts Institute of Technology; W. Lyman Underwood, lecturer on industrial biology, Massachusetts Institute of Technology; Willis R. Whitney, Ph.D., director of the Research Laboratory of the General Electric Company, Schenectady, New York; Prof. Alpheus G. Woodman, assistant professor of food analysis, Massachusetts Institute of Technology.

A GREAT LOCOMOTIVE

The Baldwin Locomotive Works has recently built a pusher locomotive to help trains over heavy grades on the Erie Road, which is remarkable in size and power. It has a third pair of cylinders and a set of six-coupled driving wheels which are carried by the frame of the tender. The steam is utilized in one pair of high-pressure cylinders and two pairs of low-pressure cylinders, all of which are thirty-six inches in diameter by thirty-two inches stroke. The drawbar pull is eighty tons, and the total weight 477½ tons.

POWERFUL BRAKES

At a recent experiment on the Pennsylvania Railway, a twelve-car steel train of nearly one thousand tons weight, running sixty miles an hour was stopped within its own length. This was a test of a new Westinghouse brake which may be operated by pneumatic or electric control, and has two shoes for each wheel instead of one.

This new device reduces the time of attaining the maximum brake capacity from eight seconds with the old brake to three and one-half seconds. With the electric control the time is shortened to two and a quarter seconds. A twelve-car steel train running eighty miles an hour could be stopped within two thousand feet.

FIGHTING THE HOUSE FLY

DESCRIPTION OF THE LATEST FORM OF FLY TRAP—SOME EXPERIMENTS SHOWING THAT THE HOUSE-FLY PUPATES IN THE EARTH

BY ERNEST C. LEVY

Extermination of the house-fly is one of our really important health measures. It is not necessary to go into proof of this today. Every health officer who has studied this question actively in the field, and not just written about it in his office or dabbled a little with it in the laboratory, is convinced that the house-fly is a very active agent in the dissemination of disease. I am going to assume that we all understand this. Moreover, it is surely fair to assume that, in many a case of illness, not itself caused by flies, the delicately poised balance between life and death may well be turned by the annoyance and loss of rest brought about by this pestiferous insect. Still again, there is abundant reason why everyone of us would like to see *Musca domestica*, and all allied species and genera, wiped off the face of the earth.

I think that up to even a year ago, most of us felt that we were engaged in a hopeless kind of fight. We felt that we could of course do a great deal, but that in spite of killing millions of flies and doing our utmost to limit the breeding of this insect, yet their tremendous prolificness—the mere brute force of their numbers—would still get the better of our ingenuity.

This is not true today. The fight against the fly is a winning fight. We now have the necessary knowledge and the necessary machinery. To make these effective, however, we need the same old thing that we need in all public health work—the coöperation of the people. This, in turn, must be preceded by education of the people.

The evolution of our work for the extermination of the fly has been somewhat slow—slow at least for these days. But we have today methods which are perfectly capable of wiping out the fly in any community within a very short time, provided always that the people understand and are ready to help us. More than this, if coöperation of all the people cannot be secured, we know how to eliminate the fly almost completely in any limited section of a city in which the local residents are sufficiently interested to carry on that part of the work which is assigned to them.

In order to fight flies successfully, we must fight them at every stage of their development. This means the keeping apart of flies and all material (especially horse manure) suitable for the depositing of their eggs; the removal, or destruction, of fly-blown material before the eggs have had time to develop into flies or into mature maggots, and the destruction of adult flies by all known means.

It is useless to expect results of a satisfactory nature if any single thing is neglected. Fly-swatting campaigns, for example, kill relatively few flies, even though the actual number killed may go into the millions. Nevertheless, fly-swatting has a decided field of usefulness, in that by this means we get rid of flies which are not reached by other methods, and which will multiply many hundredfold unless destroyed. To claim that fly-swatting is useless because only a few million flies are killed, or that it is worse than useless because these flies should never have been allowed to hatch, is altogether wrong. The life cycle of the fly is so short, from egg to egg, from maggot to maggot, from pupa to pupa, or from fly to fly, that each point precedes every other point as well as follows it. Those who contend that killing adult flies is the wrong way to proceed, because we should have prevented these flies from

ever hatching out, fail to realize that the killing of a few adult flies of a previous generation would have gone really further back than merely preventing these flies from depositing their eggs in a favorable place.

The literal swatting of flies does not, of course, get rid of any very great number of these nuisances, but in all fly-swatting campaigns dead flies are counted regardless of how they were obtained, and hence the term "fly-swatting" is frequently used as essentially synonymous with the killing of adult flies by any method whatever.

For killing large numbers of adult flies no method is so productive of results as the use of traps. By this I do not mean the small fly-traps sold for about 15 cents at hardware stores, and used about the house. Such traps are not found by the flies for a long time, and even then the number which such traps get rid of is relatively small. There are today in use traps of another kind—large affairs about two feet tall and fifteen inches in diameter. These traps are of very stout construction. They are built on the same principle as the smaller traps, but the cone ends in an opening which will admit one's thumb. The flies which once get through this opening and into the trap proper never find their way out again. These traps are, therefore, not only useful on account of the tremendous number of flies which they catch, but, speaking from my personal experience they are encouraging. When one sees flies by the thousand walking and flying about over every fraction of a square inch in such a trap without ever finding the large opening by which they entered, and out of which they could get with equal ease, one cannot fail to feel that it would be a disgrace to admit that an insect with so little sense could outwit man.

These large modern fly traps are not placed indoors, but in the case of residences they are placed in the back yard, and in the case of stores they are placed in the street near the curbstone. The manufacturers of this trap lay great stress on the rôle played by the bait which accompanies each trap. One or two drops of this bait are placed in a saucer of vinegar and put under the trap. The manufacturers claim that the bait so prepared will attract flies from a great distance, even from a kitchen in which a meal is cooking.

My own trap was built by myself at a cost of about 50 cents, and I did not find it necessary to employ any especially manufactured bait. A saucer of vinegar with a liberal sprinkling of sugar around it was in every way successful. Stale beer worked equally well. This trap caught many things besides house-flies. In fact, there was, roughly speaking, about one fly of some other kind to every two or three house-flies. These other flies were green ones and blue ones and gray ones, large and small, but the house-fly was always in evidence, outnumbering all other kinds put together. In addition to flies, my own trap caught regularly large numbers of June bugs, and at one period tremendous numbers of moths about the size of the last joint of one's thumb. Bees and wasps were also caught in considerable numbers. During the summer this one trap caught over three quarters of a million flies, calculated on a basis of 13,000 to a quart.

It can hardly be contended that even one such trap on a city block has no effect on the number of flies prevalent in that block, even though nothing else be done. In my own case, a neighbor living about ten doors from me was hatching flies throughout the summer at a far greater rate than I could catch them. Even under such circumstances, the number of flies on my block must have been lessened not merely by the 750,000 which I actually caught, but by numbers far greater than this, since the flies trapped early in the season would probably have multiplied at least a thousandfold before the end of the season.

After we get complete control over all breeding places, this special kind of trap will probably no longer play a prominent rôle, since it is not effective in dealing with the smaller residual numbers with which we will then have to deal. For this latter purpose smaller traps, tangle-

foot paper, poisons and swatting will meet the situation.

These large fly traps have another distinct field of usefulness, as illustrated by the following case: A mile or so outside of Richmond, Va., there is a very attractive suburban community. From all that I have ever been able to see, there are few, if any, horses kept in this community, and all the lots are apparently free from any large collections of material which would serve as breeding places for flies. But regularly each year this community is literally overrun with flies. It is no exaggeration to state that I have seen at least one tenth of the surface on railings and pillars of porches occupied by flies. Where they come from I have never been able to determine. It is true that I have never made a thorough investigation, but there is no section of Richmond where I have ever seen flies as prevalent as they are in this suburb. Of course, these flies breed somewhere, either within or without the boundaries of this suburb, and an investigation would ultimately determine where. Pending this, however, it would be entirely practicable for this community to reduce the number of flies to a small percentage of their present numbers if each householder would use even one of these traps and look after it properly.

It seems to me that there is room for good work in determining what is the best bait to be used in traps of this kind. It would be desirable to find a bait which would attract flies but not moths, June bugs, wasps, bees, etc., since these insects consume the sugar far more rapidly than do flies, and thus necessitate more frequent rebaiting, besides which there are obvious personal objections to dealing with a trap in which the two insects last mentioned are present.

I shall not discuss at length the very important questions of stable construction and removal of manure. It is useless to expect very good results unless these things are properly looked out for. I am inclined to believe that the statement that 90 per cent. of all house-flies in cities breed in horse manure is far below the mark, and that very small numbers breed in any other material. Even though this be so, we must nevertheless believe that in a community in which there are no horses, or in which all horse manure is so perfectly handled that it never becomes accessible to flies, house-flies would deposit their eggs in other organic matter, if such were available. In fact, I frequently found during last summer large numbers of fly eggs laid on the bare wire of my large fly trap. Whether these were the eggs of the house-fly or of one of the other 57 varieties I am unable to state, but it would appear from this as if the female fly is unable to retain mature eggs beyond a certain point, but must deposit them somewhere.

Stable floors should by all means be of tight construction. I have frequently seen maggots disappearing in cracks less than one eighth of an inch wide between wooden blocks in a stall. Whether or not such maggots pupate, and whether or not they could ever emerge as adult flies, is another question which I have not had time to look into.

Recent experiments conducted by the Richmond Health Department have caused me to hold views quite different from those generally accepted in regard to stable construction and removal of manure. These experiments have been told briefly in a paper published a few months ago.* They convinced me that the house-fly does not normally enter the pupa stage in manure if the adult maggot finds it easy to leave the manure and enter the earth. Since the paper above mentioned was written, additional experiments have been conducted by us. I will relate one of these briefly. Two wooden soap boxes, about two feet long and one and a half feet wide and nine inches deep were used in this experiment. In one of these boxes was placed fresh horse manure. This was supported on wire gauze with a mesh of about one half an inch, the bottom of this box having been first knocked off. This box was placed on top of a second one of exactly the same kind. This lower box was first filled with dry earth. The two boxes thus arranged were

*A. M. Jour. Public Health, Vol. 3, No. 7.

placed near a stable. At the end of 24 hours the manure in the upper box was loaded with eggs of the house-fly. Fine wire gauze was then nailed over the top of the upper box. The manure, meanwhile, had settled down so as to leave a space of about one inch between the upper surface of the manure and the fine wire gauze. Maggots developed promptly, but three days after the beginning of the experiment all the maggots had apparently left the manure box. Examination of the lower box at this time showed it to be swarming with large maggots. We then separated the two boxes and screened the lower one, which, to repeat, contained finely divided earth. We got thousands of flies from the box of earth, but not one from the box of manure, nor did careful examination of this manure show a single maggot or pupa. In other words, every maggot had left the manure and gone into the earth.

Our experiment went even further than this. The wooden bottom of the lower box (the one containing the earth) had in it several small holes and cracks which we had failed to notice. Not only did all the maggots go through the nine inches of manure in order to get to the earth in the lower box, but a very considerable number of them continued on down through the nine inches of earth in the lower box, and then got out of this box through the holes and cracks above mentioned, as was shown by the fact that we found in the earth immediately under this box, and for several feet around it, maggots and pupæ. This experiment surely sustains our point—namely, that the house-fly does not normally pupate in manure but in earth.

COLOR COMPOSITION OF LIGHT

In a recent paper on the "Physics of Lighting," Dean F. L. Bishop of the University of Pittsburg discussed the various methods of producing the physiological effect of light, stating that the normal eye being equally sensitive to red, blue and green light, that a black body heated 6000° C., gives these light values in equal proportions, producing white light; but such a temperature is not commercially practicable.

The color composition of familiar light sources are presented in the following table.:

	Red	Green	Blue
Light from north sky	32.2	32.2	35.8
Overcast sky	34.6	33.9	31.5
Afternoon sun	37.7	37.3	25.0
Hefner candle	55.0	38.8	6.2
Carbon incandescent lamp	51.3	40.4	8.3
Mercury-vapor lamp	29.0	30.3	40.7
Moore lamp, with carbon dioxide	31.3	31.0	37.7

SCIENCE CONSPECTUS

VOL. IV 1914 No. 3

ELEPHANTS AND THEIR PROGENITORS

THE STORY OF THE EVOLUTION OF THE ELEPHANTS OR PROBOSCIDEA FROM THEIR EARLIEST RECORDED ANCESTOR, THE MŒRIS BEAST

BY RICHARD SWANN LULL

THE elephants seem so essentially foreign to the New World that one is surprised to hear of their former existence as a conspicuous element in the past fauna of North America, and especially of the discovery of at least six specimens of the prehistoric mastodon within the confines of New England, of which one, discovered at Colerain, Massachusetts, was a denizen of what, years later, was to be part of the Commonwealth itself.

The elephants, standing as they do, so utterly aloof from all other mammals, are nevertheless related on the one hand to the conies (*Hyrax*) of Scripture, the feeble folk that make their houses in the rock (Proverbs, xxx, 26), and on the other to the Sirenia or sea cows, exemplified by the manatee of Florida. The resemblance is in neither case apparent, for, in the one instance, disparity of size is remarkable, and in the other, difference of habitat, but the remote ancestors of all were the same and the resultant divergence is largely the result of habits and environment.

The evidence for the evolution of any group of forms is threefold. First, the anatomy of the creature in comparison and contrast to that of other forms; secondly, the ontogeny or individual life history from conception to death, which according to Haeckel gives a brief though somewhat distorted summary of the evolutionary history of the races, and third, the documentary evidence; that of the fossil representatives found in the older and older rocks, which when placed in proper sequence and properly interpreted is final and unassailable proof.

Elephantine anatomy is an abundant source of knowledge; the ontogeny has taught us little, mainly from dearth of material; while the fossil record as far back as it goes is very full and complete.

ANATOMICAL EVIDENCES

The elephants show a curious intermingling of archaic and highly specialized features, the body, aside from its increase of size, changing but little as time goes on, the head undergoing a most remarkable modification. The archaic features are mainly in the feet, the retention of five—the original number—toes, though the nail-like hoofs may be fewer. The bones of the wrist are arranged serially, that is, one above another, in contrast to their alternating position in most mammals, especially those in which the foot is subjected to splitting strains. The limbs are primitive also in

the retention in the forearm and lower leg of two well-developed bones, one of which in each member tends to be reduced when an animal is modified for speed. In its soft anatomy, as well, the elephant shows several ancient characters as compared with the host of its contemporaries; among them being the general form of the brain, although, as we shall see, it is also highly specialized.

The specializations are, first, immense size, which is much greater than that of any terrestrial creature the world has ever seen, only excepting the ancient dinosaurs of the Mesozoic period. A typical and very well-known elephant would be "Jumbo" whose height was eleven feet, with a weight of six and a half tons. In order to carry this immense bulk the limbs have become pillar-like in contrast to the sharply angulated limbs of the horse.

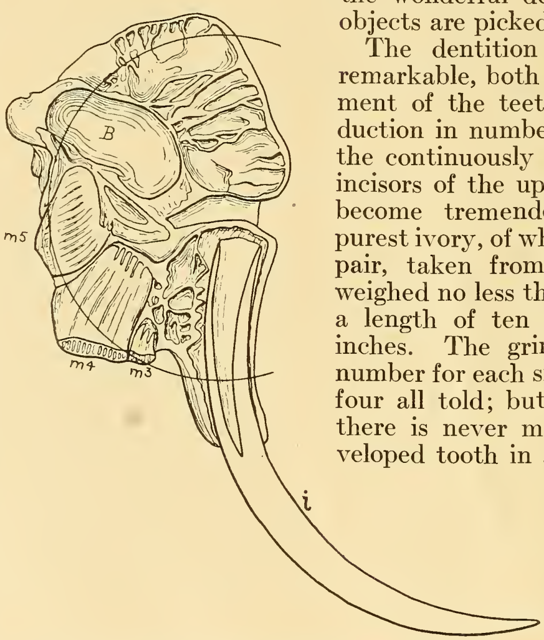


Fig. 1.—Sectioned skull of Indian elephant; after Owen

The head shows several lines of marked change, all of which are, however, interdependent upon one another. They are, first of all, an alteration of the form of the skull, which becomes relatively shorter and higher to provide greater leverage for the huge muscles of the neck to meet the increasing weight of trunk and tusks. This is accomplished, not so much by the increase in the actual size of the brain cavity as by the separation of the outer and inner surfaces of the skull bones and the development of air spaces or diploë between them. This form of the bone also extends to the upper jaw to provide space for the huge teeth. In the skull of the newborn elephant this feature is not shown but develops with age just as it has in time—almost the only evidence which ontogeny casts upon the evolution of the skull. The proboscis, perhaps the most distinguishing elephantine feature, is a wonderfully complex muscular organ, the combined nose and upper lip terminating in one (Asiatic) or two (African elephant) finger-like processes, so that the trunk combines the strength sufficient to uproot a tree with the wonderful delicacy whereby minute objects are picked up from the ground.

The dentition of the elephants is remarkable, both for the great enlargement of the teeth and the extreme reduction in number. The tusks represent the continuously growing second pair of incisors of the upper jaw and they have become tremendous structures of the purest ivory, of which the largest recorded pair, taken from an African elephant, weighed no less than 463 pounds and had a length of ten feet, three and a half inches. The grinding teeth are six in number for each side of each jaw, twenty-four all told; but because of their size there is never more than one fully developed tooth in a jaw at any one time, though one partly developed and one partly worn out may be simultaneously in evidence. Each tooth consists of as many as twenty-seven transverse plates of ivory or dentine, overlaid by enamel and separated from one another by the cement which serves to bind the entire tooth together. These three substances differ in hardness, so that the enamel which is the most resistant stands above the other substances in the partly worn tooth as a series of ridges separated by shallow valleys, thus forming a splendid grinding device. The method of tooth replacement from behind forward is also unique, the teeth moving toward the front of the jaw through the arc of a circle as fast as they are worn away, while the full

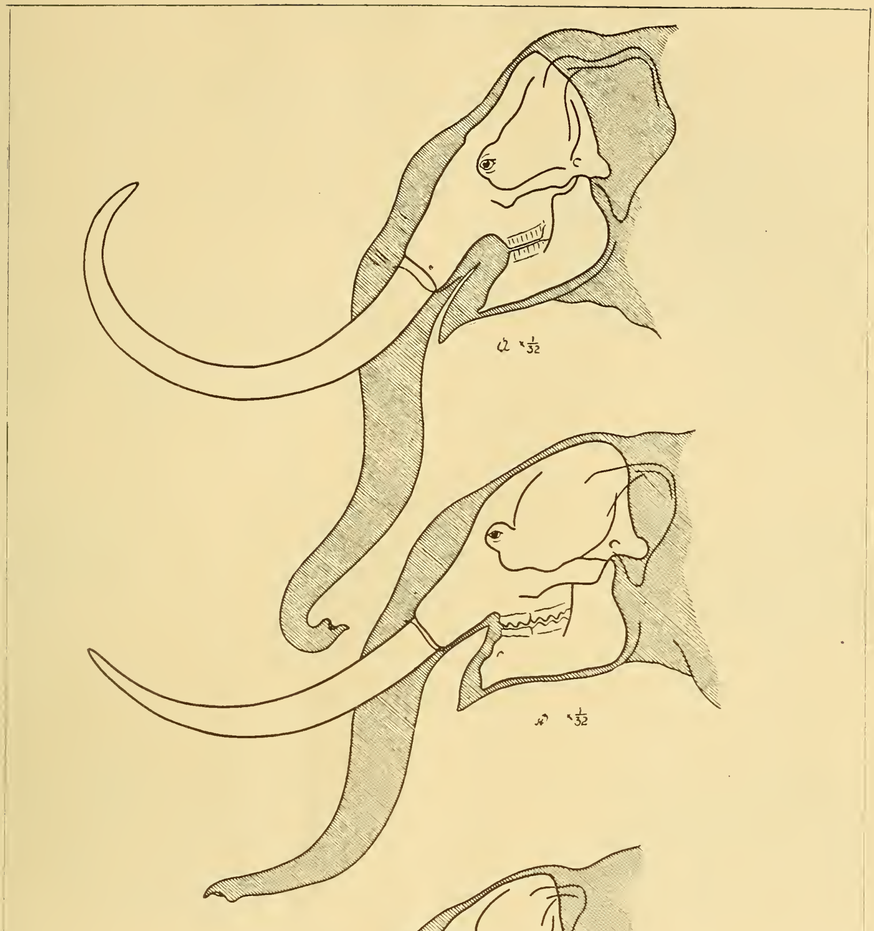


Plate I.—Evolutionary changes of Proboscidia. Based upon restorations modeled by R. S. Lull.
a, Elephas columbi; *b, Mammut americanum*; *c, Tetrabelodon angustidens*; *d, Palæomastodon*; *e, Mœritherium.*

amount of tooth substance produced is nicely calculated to last the creature's possible lifetime of a century or more.

The brain, characterized as it is by great size, at least twice that of mankind, is also very well convoluted and is the seat of an intelligence second only to that of the higher apes and carnivores.

Doubtless, as in the case of mankind, much of the higher mentality is due to the elephant's ability to lift objects before its eyes for examination. The intelligence of the elephants has, however, been both exaggerated and minimized. Elephants possess a remarkably memory of injuries, real or fancied, of misfortunes, and of the time and place of the ripening of favorite fruits. They also learn to perform complex labors, as the carrying and piling of logs in the teak yards in India, without other directions than the initial order. They are said to be weatherwise and to be able to foretell rain some days in advance. Elephants are obedient and docile, notably those of India, but the males especially are subject to periods of nervous excitement, apparently of a sexual nature, known as "must," when they become very dangerous and sometimes destroy the keepers in their paroxysms of rage. Ultimately all male elephants become surly and intractable. In the wild state such are known as rogues and live apart from their kind until they die. Elephants are rightly accused of timidity and cowardice, though when brought to bay rage may simulate courage, making a charging tusker a formidable foe. In common with most forest and jungle dwellers, elephants, while relatively dull of sight, are keen of scent and hearing, in fact marvelously so, for, as Schillings tells us, they either have an acuteness of some known sense far beyond our comprehension or possibly some other sense unknown to us. The sentinels of the herd stand with uplifted trunk, which emphasizes the value of the sense of smell.

Elephants rarely breed in captivity, almost all of the tamed individuals having been born wild; hence artificial selective breeding, which has given rise to such valuable results in the betterment of domestic animals, is unavailable for the improvement of the race. The slow rate of increase, however, implies some most effective check in the struggle for existence, for aside from man the elephant has no known enemy today, in spite of which fact its total numbers do not increase.

SUMMARY OF EVOLUTIONARY CHANGES

Notable among these are the increase in size, and the change in the form of the skull from the long, low type seen in the earliest known ancestor to the short, high cranium of the living form. The evolution of the tusks is also very remarkable, for at first there were four, two in the upper and two in the lower jaw. Of these the lower ones projected straight forward and were used for digging, while the upper ones curved downward instead of upward as in the later types. As time went on, the lower tusks elongated, together with the union or symphysis of the jaws, until about midway in the evolutionary sequence they reached a mechanical limit of utility. The jaw then rapidly shortened and the lower tusks disappeared except in the males of the persistently primitive American mastodon, which retained until their extinction one or two relatively small and apparently functionless relics of these teeth. In the living elephants the short spout-like projection of the lower jaw is a vestige of its old elongation. The trunk had its first inception doubtless merely as a short prehensile or grasping lip which aided in securing food. With the elongation of the jaw this lip lengthened as well, forming with the nose the continually extending proboscis, which, while it kept pace with the growing jaw, was of necessity limited in its range of usefulness, until with the secondary shortening chin it became the pendant organ the elephants now possess.

The teeth increased the number of the transverse ridges, which at first were relatively few, with no intervening cement, until the complex grinding device was perfected; they also reduced in number and changed their mode of succession from the normal vertical sequence of milk and permanent dentition usual

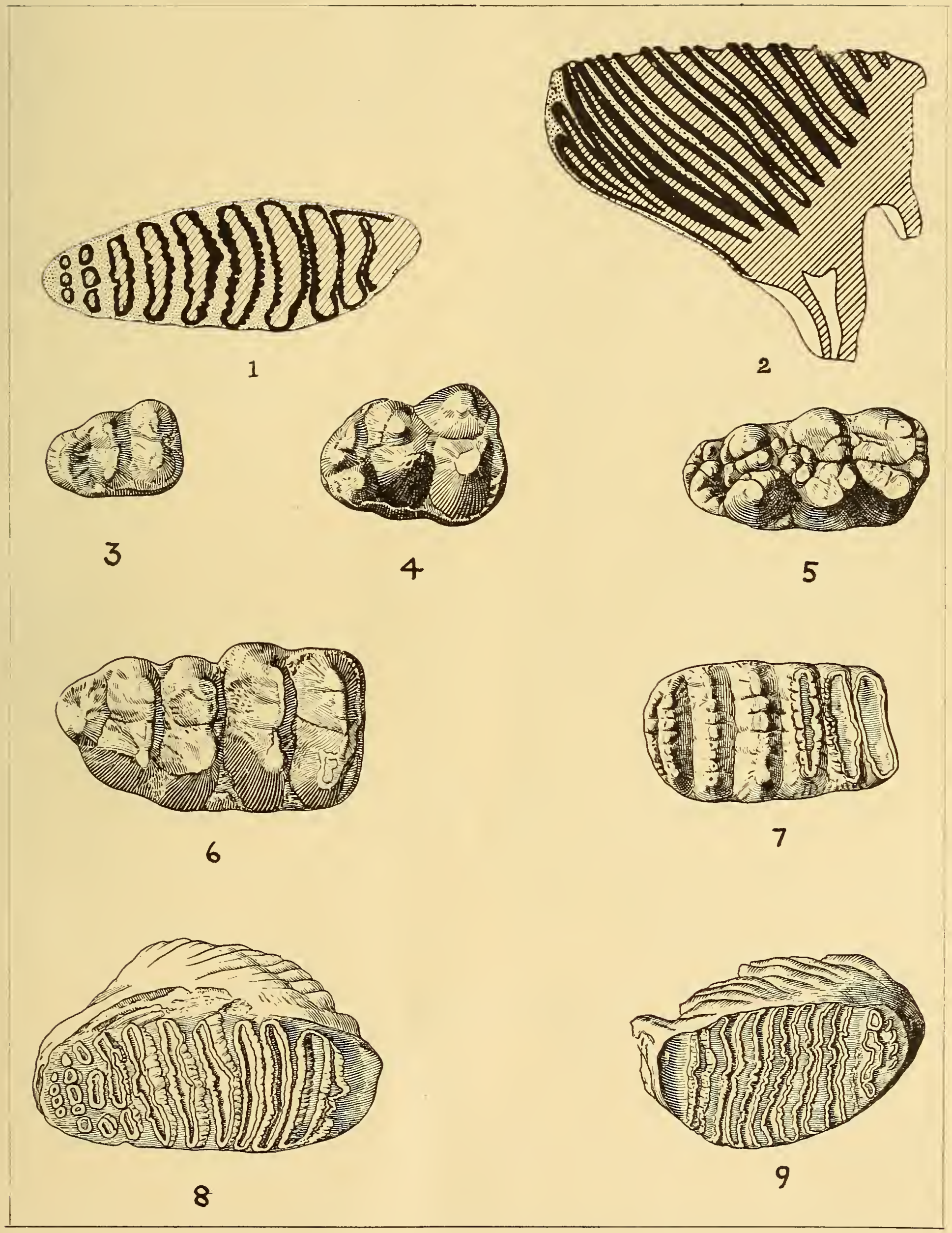


Plate II.—Figs. 1, 2, Crown view and section of a proboscidian molar tooth. Figs. 3–9, Evolutionary changes in teeth of Proboscidia; *3, Mœritherium; 4, Palæomastodon; 5, Tetrabelodon angustidens; Mammut; 7, Stegodon; 8, Elephas imperator; 9, E. columbi*

with mammals to the linear succession of the elephants.

FOSSIL RECORD

The science of palæontology has brought to light a marvelous evolutionary series of more or less complete elephants from their first recorded appearance to the present time. The oldest relics were found not many years since (1901) in the region known as El Fayûm in Egypt, about fifty-seven miles south and west of Cairo near the present Lake Birket-el-Qurûn, itself a brackish relict of the larger, artificially controlled, fresh water Lake Mœris. Along the northern shores of old Lake Mœris there are extensive deposits of Tertiary rocks wherein are entombed more or less abundant relics of a past fauna, conspicuous among which are those of the ancestral elephants. Of these the oldest, in strata of Middle Eocene age, is the Mœris beast, *Mœritherium*, probably a proboscidian but also not far removed from the ancient Sirenian stock. *Mœritherium* is not completely known but evidently stood two and a half to three feet at the shoulder, with simple teeth fitted for the succulent

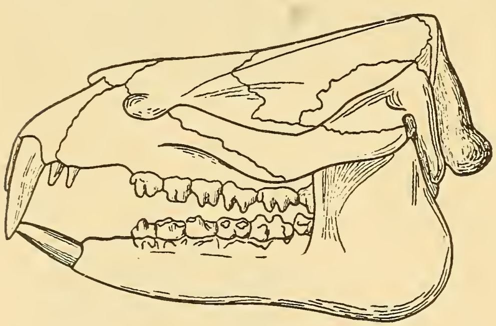


Fig. 2.—*Mœritherium* skull; after Andrews

semiaquatic herbage of that day. The skull is long and low but the hinder part of the cranium is already beginning to develop the air cells or diploë and the nasal bones are commencing to recede, indicative of an incipient trunk. The lower jaw with its procumbent tusks is only slightly elongated, and, while the upper tusks which are the second pair of incisor teeth, are well developed and dagger-like, the other incisor teeth (the first and third) as well as the canine teeth are present.

The Fayûm has also yielded *Palæomastodon*, the successor to *Mœritherium*, in beds of Upper Eocene and Oligocene age. This animal is more elephant-like than

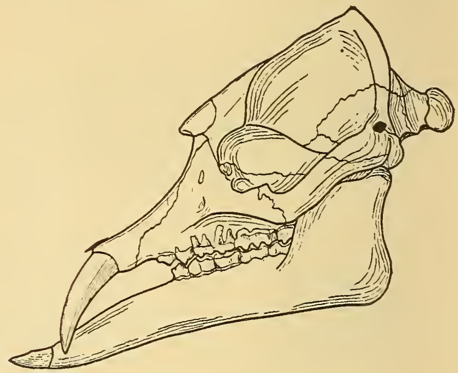


Fig. 3.—Skull of *Palæomastodon;* after Andrews

its predecessor and is larger in size, standing four and a half feet in height. The skull has heightened materially, with a considerable development of air cells in the bones. The small nasals with the narial openings have receded so that they lie just in front of the orbits as in the modern tapir, which would indicate a short extensile proboscis essentially like that of the modern elephant except for size. There is but one pair of tusk-like teeth remaining in the front of each pair of jaws and of these the upper ones, particularly, are large and downward curved, with a band of enamel on their outer face. The lower jaw shows a considerable elongation.

The third recorded stage in the evolutionary series is *Tetrabelodon*, Miocene form and a world-wide wanderer, for this is the proboscidian which escaped from the confines of the Dark Continent, probably by way of a temporary land bridge of which Sicily, Malta and Italy are latter-day relics. *Tetrabelodon* is known in Africa, Europe, Asia and even in North America. It was an animal of considerable size, nearly as large as the living Asiatic elephant, and with a body essentially elephantine in its contour;

the great contrast lay, however, in the immensely elongated lower jaw, which reached the maximum possible from the point of view of an efficient mechanical device. The upper tusks are still downward curved and continue to possess the enamel band. The proboscis was fully developed but limited in its range of utility by the rigid lower jaw. The teeth are quite complex and have attained such size that but two adult grinders can be contained within the masticating limits of each jaw at any one time.

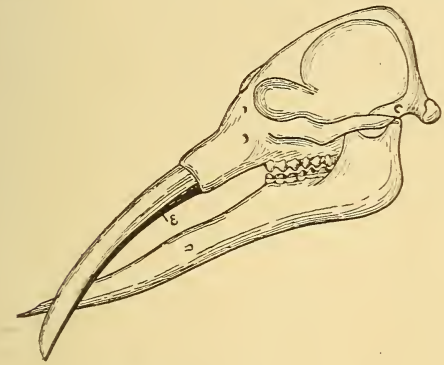


Fig. 4.—Skull of *Tetrabelodon angustidens*

Tetrabelodon was succeeded by *Dibelodon*, in which, while the upper tusks still retained the enamel, the lower ones had disappeared and the symphysis was reduced to a spout-like prolongation, relatively longer, however, than in succeeding types. *Dibelodon* is known from the rocks of Pliocene age in both North and South America, and seems to have been the only proboscidian to cross the newly emerged land bridge of Panama. Why none of its successors, except possibly an isolated imperial mammoth, ever succeeded in reaching South America we do not yet know.

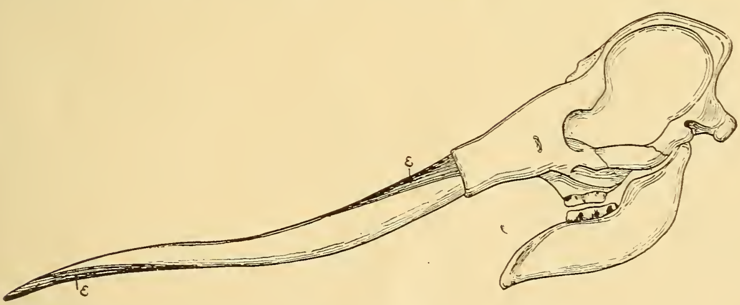


Fig. 5.—Skull of *Dibelodon andium*

Another Old World derivative of *Tetrabelodon* was the great mastodon (*Mammut*) which also ranged to North America, where it persisted until after the final extinction of the mammoth and may have been a contemporary with pre-Columbian man. In the mastodon, the large upward curved upper tusks had no enamel; as I have said, the lower ones are sometimes present, though one only may persist of the original pair. The teeth are large, low-crowned, with four or five transverse crests, and are adapted to browsing upon succulent vegetation. In stature the animal was not very tall, seldom exceeding ten feet, but it was ponderous of bulk, and this, together with its low-crowned head and coarse, hairy covering must have given it a very archaic aspect.

Another curious proboscidian, evidently an aberrant side line of unknown ancestry, is *Dinotherium*, found in Miocene and Pliocene strata of Europe and Africa. While the body was again elephant-like in every detail, the skull was very low and flat and bore no *upper* tusks at all. The lower jaw, however, was recurved at the symphysis and the sharp inferior tusks pointed downward and slightly backward. The teeth, which had but two crests, were very primitive and had the normal mode of succession, indicating that *Dinotherium* diverged from the main proboscidian stem very early in the evolutionary history of the race.

Certain transitional elephants, known as the Stegodons, had teeth midway between those of the mastodons and true elephants. These forms shortly gave rise

to the final stage of the race, *Elephas* itself. They seem to have had their origin in India, whither their ancestors went and whence they migrated to Africa, back to Europe, to the rest of Asia, and finally to North America, so that their wanderings were well-nigh world-wide.

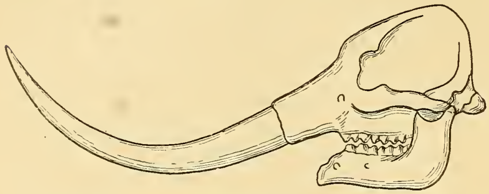


Fig. 6.—Skull of the American mastodon

Of the true elephants three were known in Europe and three in North America, one of which was common to both the Old World and the New. Of the American types the oldest in point of time was *Elephas imperator*, the imperial mammoth, Pliocene and early Pleistocene in time and widespread over what is now the United States and Mexico. This majestic type has never been rivalled, for it stood thirteen and a half feet at the shoulder, with tusks ten feet or more in length and with huge, coarse ridged teeth. The imperial mammoth was succeeded by *Elephas columbi*, whose stature rarely exceeded eleven and a half feet, but whose tusks reached the maximum of length and curvature, those of an old male actually crossing each other at the tip so that their primal function of digging was lost, nor could they have served as very efficient weapons. They have been looked upon as instances of "momentum in evolution," structures which, long past the point of greatest efficiency, became an actual menace to the owner.

The Columbian mammoth merges almost insensibly into the woolly mammoth, *Elephas primigenius*, of the Glacial period, and may have been its actual ancestor, but the evidence for this is not yet clearly demonstrated. The woolly mammoth or "The Mammoth" as it is generally called, was circumpolar in distribution, extending from England across Europe, northern Asia, and North America, where its range overlapped that of *Elephas columbi* along the southern frontier. The mammoth was about the stature of the living Asiatic elephant, from seven to nine feet. It was guarded against extreme cold by a heavy woolly undercoat covered by longer hair. The tusks were of two sorts, short and relatively straight, or long and curved, which was possibly a sex distinction. When one learns that the mammoth tusks (which constitute perhaps one-half the annual output of commercial ivory) thus far secured represent no fewer than forty thousand individuals, he realizes the enormous numbers of these creatures which formerly existed. Entire mammoths are found occasionally in the frozen soil of Siberia, three instances of which are notable. One from the Lena Delta was secured in 1806 and may be seen with part of the hide still adhering to the skeleton in the Zoölogical Museum of the Imperial Academy of Sciences in St. Petersburg. A second from Beresovka was discovered in 1901 and is also mounted in St. Petersburg, the skin in the constrained posture in which the creature died, the skeleton in walking position beside it. The latest find is now being prepared for exhibition at the Muséum

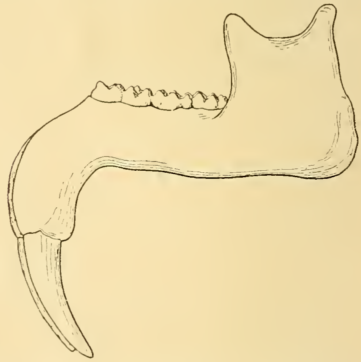


Fig. 7.—Jaw of *Dinotherium;* after Kaup

d'Histoire Naturelle at Paris, and comes from the great Liakoff Island in the New Siberian archipelago. When the exhaustive analysis of this last-found creature shall have been completed, our knowledge of the anatomy of this prehistoric form will be practically as great as of that of the existing elephants.

PREHISTORIC ELEPHANTS AND MAN

Direct evidences of the association of man and the mammoth are plentiful in Europe but, strangely enough, absolutely wanting in North America, although we have every reason to believe that such an association existed in the New World as well as in the Old. In Europe not only have the bones of man and the mammoth been found intermingled in a way that implied strict contemporaneity, but still more striking evidence is shown in the works of prehistoric artists. The fidelity with which the mammoth is drawn indicates that the artist must have seen the animal alive.

One of the most notable of these relics is an engraving of a charging mammoth drawn upon a fragment of mammoth tusk found in a cave dwelling at La Madelein in southern France. In the Grotte des Combarelles (Dordogne), France, there are, in addition to some forty drawings of the horse, at least fourteen of the mammoth. These are mural paintings or engravings, the former being executed in a black pigment and some kind of a red ocher, while the latter are scratched or deeply incised, sometimes embellished with a dark coloring matter (oxide of manganese). It is especially interesting to note that the people of that day were sufficiently advanced to have artists of a very high order.

In the caverns of Font-de-Gaume in southern France there are at least eighty pictures, largely those of reindeer, but including two of the mammoth. The actual association of man and the mammoth in America has not been proven. In Afton, Oklahoma, is a sulphur spring from which have been brought to light remains of the mammoth (*Elephas primigenius*) and mastodon (*Mammut americanum*) and numerous other animal remains, such as the bison and prehistoric horses. In the spring were also found numerous implements of flint, mainly arrowheads. This naturally was first interpreted as an instance of actual association of mankind and the elephants, but careful investigation proved that the elephant remains far antedated the human relics, and that the latter were votive offerings cast into the spring by recent Indians as a sacrifice to the spirit occupant, the bones being venerated as those of their ancestors (Holmes). Another instance, not of the

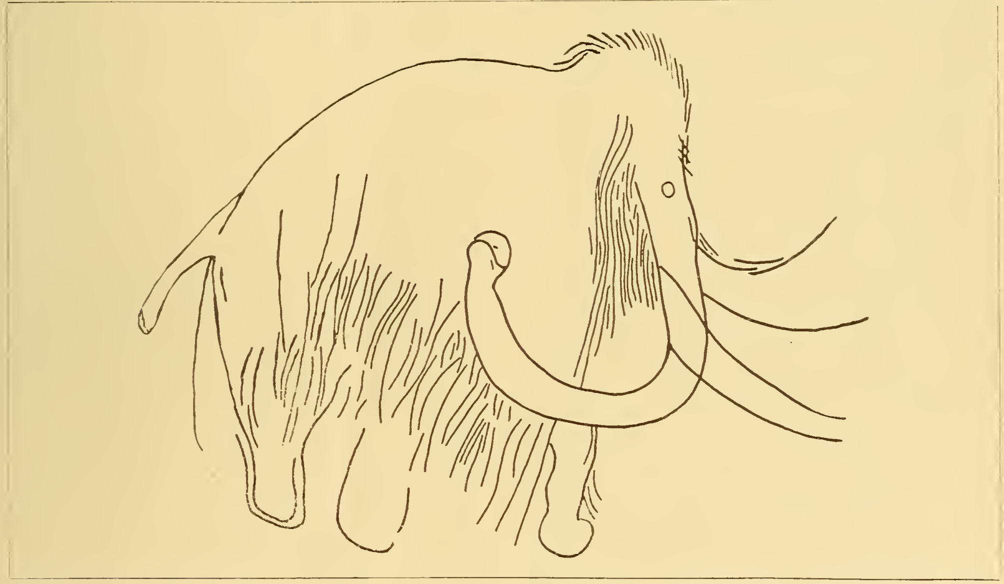


Fig. 8.—Prehistoric engraving of mammoth on wall at Combarelles; after MacCurdy

association of the mammoth with mankind, but of the mastodon, is probably authentic. This was in Attica, New York, and is reported by Prof. J. M. Clarke. Four feet below the surface of the ground, in a black muck, he found the bones of the mastodon, and twelve inches below this, in undisturbed clay, pieces of pottery and thirty fragments of charcoal (Wright). The remains of the mastodons and mammoths are very abundant in places, the Oklahoma spring already mentioned producing one hundred mastodon and twenty mammoth teeth, while the famous Big Bone Lick in Kentucky has produced the remains of an equal number of fossil mastodons and elephants.

Indian tradition points but vaguely to the proboscidians, and one can not be sure that they are the creatures referred to, yet it would be strange if such keen observers of nature as the American aborigines should not have some tales of the mammoth and mastodon, if their forefathers had seen them alive. One tradition of the Shawnee Indian seems to allude to the mastodon, especially as its teeth led the earlier observers to suppose that it was a devourer of flesh. Albert Koch, in a small pamphlet on the Missourium (mastodon) discovered by him in Osage County, Missouri, and published in 1843, gives the tradition as follows:

"Ten thousands moons ago, when nothing but gloomy forests covered this land of the sleeping sun—long before the pale man, with thunder and fire at his command, rushed on the wings of the wind to ruin this garden of nature—a race of animals were in being, huge as the frowning precipice, cruel as the bloody panther, swift as the descending eagle, and terrible as the angel of night. The pine crushed beneath their feet and the lakes shrunk when they slaked their thirst; the forceful javelin in vain was hurled, and the barbed arrows fell harmlessly from their sides. Forests were laid waste at a meal and villages inhabited by man were destroyed in a moment. The cry of universal distress reached even to the regions of peace in the West; when the Good Spirit intervened to save the unhappy; his forked lightnings gleamed all around, while the loudest thunder rocked the globe; the bolts of Heaven were hurled on the cruel destroyers alone, and the mountains echoed with the bellowings of death; all were killed except one male, the fiercest of the race, and him even the artillery of the skies assailed in vain; he mounts the bluest summit that shades the resources of the Monongahela, and, roaring aloud, bids defiance to every vengeance; the red lightning that scorched the lofty fir and rived the knotty oak glanced only on this enraged monster, till at length, maddened with fury, he leaps over the waves of the West, and there reigns an uncontrolled monarch in the wilderness, in despite of Omnipotence."

EXPERIMENTS IN ANABIOSIS

Professor Bachmetief, a Russian scientist, has been making experiments with a view to ascertaining whether anabiosis, or suspended animation of the vital functions, can be produced in the higher organisms as well as in the lower forms of life. He found upon examining insects in decreasing temperatures that death would occur at −10 degrees centigrade. Death was at first thought to be due to the freezing of the humors, but it was found that these froze at 5 degrees. At temperatures between 5 and 10 degrees, this strange condition of anabiosis occurs. Animals in this state can be repeatedly revived, even after a considerable time, by a gradual rise in temperature. Experiments were afterwards made on bats and white mice.

Professor Bachmetief was making his experiment with a view of finding a safe cure for tuberculosis, it being known that the microbes producing this disease will die at −6 degrees centigrade. The professor expresses the opinion that it would be advantageous to produce anabiosis in domestic animals that are unproductive in the winter, and to restore them to life when required.

We have also referred in Science Conspectus to experiments which have been made in producing anabiosis in fish for the purpose of transporting them long distances.

THE INLAND WATERS OF MASSACHUSETTS

HOW THE MASSACHUSETTS DEPARTMENT OF FISHERIES AND GAME IS STOCKING INLAND WATERS WITH THE FISH BEST ADAPTED TO THE ENVIRONMENT

BY DAVID L. BELDING

THE supremacy of her salt water fisheries, as typified by the historic codfish, in the past has overshadowed the inland fishery resources of Massachusetts; but we must not forget that our Commonwealth possesses many beautiful lakes, ponds, and streams, capable of producing an abundance of food and game fish. At the present time few of the 100,000 acres of inland waters are producing anywhere near their maximum or even normal possibilities. It is, therefore, important, both in the interests of sport and as a source of food supply, that these latent assets should be developed for the benefit of the public.

In colonial days, when a relatively small population was scattered along the sea coast, leaving the inland waters in their primitive uncontaminated condition, the abundance of salt and fresh water fish was far in excess of the needs of the colonists, thus giving rise to the fallacy, which has been zealously handed down to the present generation, that "Nature would always provide an abundant supply of fish." Even in this era of conservation this mistaken idea is still deeply rooted among the inhabitants of our shore towns, and it can only be eliminated by the complete exhaustion of the natural supply or by the education of the general public.

With the advancement of civilization, great changes have taken place in our waterways. Many times the balance of nature has been overthrown and a new equilibrium established. With the increase in population, the coastal streams were first invaded; cities were established on the larger rivers and various manufacturing industries were likewise scattered along the smaller streams. In order to supply water power, numerous dams were constructed, in most instances unprovided with suitable fishways, thus preventing the passage of such fish as the salmon, shad, striped bass, alewife, smelt and white perch up the coastal streams to their spawning grounds, and in this way not only depleting the supply of these fish, but indirectly affecting the commercial sea fisheries by destroying a food supply which attracted the larger predacious fish to our shores. Manufacturing wastes and sewage, particularly in the central part of the Commonwealth, have totally ruined many streams, and have seriously depleted the supply of fish in others, by rendering the water unfit for fish life. Numerous legislative measures have been enacted in the past, but the decline has steadily continued as these laws were either inadequate or, as more often the case, were not enforced. Likewise, overfishing has depleted local supplies and has accelerated the general decline which is so marked in the Merrimac, Charles, Taunton and Connecticut rivers.

For the purpose of checking this depletion by stocking public waters with fry and fingerling fish, the Massachusetts Department of Fisheries and Game was established in 1866. In the early days, salmon and shad hatcheries were located on the principal rivers as long as any native fish remained; but during the last twenty years brook trout have formed the main output of the state hatcheries. In the past the fish, which have been reared in considerable numbers at the hatcheries, have been indiscriminately dumped into various ponds and streams. In some cases this hit-or-miss stocking has been successful; in others it has been a complete failure, resulting in financial loss, since the environment was not suited

to the life of the fish. The method of stocking which has been used up to the present time in Massachusetts is of little value; results have been inconsistent; streams and ponds have been stocked with the wrong species of fish; and considerable money has been expended without entirely satisfactory results.

It was evident, several years ago, that such a prodigal method should be abolished, and that methods of stocking upon a definite economic basis should be devised in order to obtain the best results for the money expended. Such results can only be obtained by intelligent stocking, whereby fish are put into waters suitable for their best development. It can be conservatively stated that, with proper scientific methods, the production of the inland waters of Massachusetts can be increased at least tenfold over the present output. The benefits derived from the proper development of the inland waters are (1) increased facilities for sport and recreation; (2) more business from vacationists; (3) a larger food supply; and (4) a greater number of cottages and pleasure resorts upon our lakes.

As the first step toward formulating a systematic basis for future stocking, a survey of the inland waters was begun in 1911. The first part, the lakes and ponds, has been finished, while the second, the streams, is at present incomplete. The preliminary step in this work was to ascertain the present condition of the fresh water ponds. Massachusetts has within her borders approximately 875 ponds over twenty acres in area, some of which are used for water supplies by the various towns and cities, others which are artificial, but the majority of which are natural, public ponds, capable of development.

The object of the work was (1) to increase ultimately the supply of food fish and game fish in the public waters; (2) to study the food, growth, spawning, and habits of the different species of fish inhabiting these waters; (3) to determine the species of fish best adapted to certain classes of water; and (4) to make a biological survey of the ponds for the purpose of obtaining the species and quantity of fish, the natural conditions influencing the life of these fish, and to establish permanent records for future stocking.

The general work consisted of two parts: (1) an extensive biological survey of the ponds in regard to their general conditions, to form a guide for future stocking, thus classifying the ponds into certain groups according to the similarity of the natural conditions; (2) an intensive study of various type ponds, representing the groups above mentioned, as regards the effects of the natural conditions upon fish life. In these ponds, records of the temperatures, amount of food (plankton), and the general changes which concern the problem of fish life were followed throughout the year. The work on the type ponds will serve as a basis for interpreting the conditions in the other ponds which, as a rule, fall into five classes. The types under observation present large and small ponds, both deep and shallow, in which the conditions as regards the species, growth and abundance of fish are quite different. The scattered distribution of the water systems allowed but a short time in the general survey for the examination of the individual pond. In every instance the following information concerning the physical characteristics was obtained in order to insure the proper classification of each type:

Name.—The name of a pond is a variable factor. Usually a pond has several names, according to the various maps upon which it is recorded, and often these listed names are unknown in the immediate vicinity where local titles are in vogue. To facilitate the identification of any body of water for public information or for stocking, the primary essential is the recording of all the names by which it is known.

Names, themselves, are interesting as illustrating popular origin. For instance, on Cape Cod, near the ocean, are many Herring Ponds, the name arising from the fact that the alewife or branch herring enters from the ocean through a tributary stream each spring to deposit its spawn. Frequently ponds are named

from their size, shape or general characteristic, *i.e.*, Long, Great, Shallow, Marsh, Muddy, Sandy, Grassy, and Six-Mile. Still other ponds are named after birds, as Swan, Duck, etc., or after the prevailing vegetation as Lily or Cranberry. From the clearness of the water we find the names of Clear and Crystal, too frequently a misnomer at this present time. Among the artificial ponds, the name Mill Pond often occurs, while others have possessive names from the owners or locality. Another class, by far the most interesting, still retains the old Indian names, such as Catacoonaug, Massapoag, Unkechewhalon, Charggoggagoggmanchauggagoggchaubunagungamaugg, etc.

Location.—The situation of the pond as to ease or difficulty of access from railroad stations or nearest village as well as the hotel and boating facilities were recorded for use in future shipment of fry and as a source of information to fishermen.

Area.—No actual survey of the area of the ponds was made, the size being measured from maps or taken from old records.

Depth and Bottom.—Soundings were so made that contour lines, giving the depths, could be charted on diagrams of the ponds, and from these measurements the average and maximum depths were ascertained. The sounding lead was equipped to take samples of the bottom soil, but, unfortunately, on hard or mossy bottom no soil could be gathered by this method, and the nature of the bottom could only be determined in shallow water or from the character of the shores.

Water.—The color of the water was listed as either clear, green or brown. The turbidity was expressed in feet, the number representing the distance below the surface at which a white four-inch circular disc would disappear from view. By means of the maximum and minimum thermometer, the temperature at the bottom was taken in various parts of the pond to determine the presence of springs. In the deepest part, a series of readings were taken at intervals from $2\frac{1}{2}$ to 5 feet to determine the thermocline, or point where the temperature drops rapidly. Deep ponds have three layers of water—a surface layer in which the temperature to a depth of 15 to 20 feet remains approximately the same as at the surface; a middle layer or thermocline in which there is a rapid fall; and a bottom layer of uniformly low temperature. The extent and nature of these three layers, which vary in different ponds and at different seasons of the year, are of importance as regards fish life, from the standpoint of food and oxygen.

Shores.—The shores around the pond were classified as woodland, the kind of trees usually being noted, fields cultivated and uncultivated, such as pasture or meadow, and marsh land. The height and slope of the shores and character of the beach were likewise noted. Cottages, hotels, gunning stands, icehouses, etc., were recorded as indicating the popularity of the pond as a pleasure resort.

Inlets and Outlets.—The inlets and outlets with the volume of water, temperature, amount of sediment and pollution, such as manufacturing waste or sewage, were described. The presence of a dam at the outlet indicated that the pond had either been raised above its original area or that it was wholly artificial. In certain instances it was practically impossible to definitely determine whether a pond thus raised was originally a state pond, ten acres in size, open to the public.

Fish.—Information concerning the different species of fish was obtained from fishermen and people living in the immediate vicinity who were acquainted with the pond. In the rapid survey, it was manifestly impossible to obtain this information in any other way, and for this reason the question of the quality of the fishing and the present production of any pond was only determined in a general way, since the term "good fishing" is but relative, varying with the locality.

Fish Food.—A pond, as defined by the dictionary, is a body of fresh water usually less extensive than a lake. The word "pond" should, however, have a broader meaning. It includes all the organic life within its boundaries, which makes it a complex whole, a perfect unit of animal

and vegetable life. A pond can be likened as it were, to a large organic molecule composed of many atoms, the different species which compose it. But this huge molecule is never stable. Changing conditions are constantly arising in the struggle for existence between the numerous species which inhabit its waters. Therefore, whatever affects any species, no matter how small, changes the interrelations of the whole, and particularly affects the food supply of the fish. The large fish prey upon the small, and the small in turn feed upon the minute floating animal and plant forms in the water. For this reason, the amount of fish that a pond can support depends directly upon the amount of small organisms in the water, and a study of the fish food necessitates a study of the complex life in the whole pond. For this reason, observations upon the animal and plant life, especially the aquatic vegetation which furnishes the brood grounds for the microscopic fish food, are valuable.

The study of fish food was undertaken in two ways: (1) the examination of the stomach contents of various species, both of the small and large fish, under various conditions and at different seasons; (2) the determination of the nature and amount of the floating organisms, plankton, in the different ponds by means of the plankton net of silk bolting cloth. The work was placed on a rough quantitative basis by making careful vertical hauls from the bottom to the surface and by estimating the amount of water thus filtered. The contents were washed into a copper cup at the end of the net, and then transferred to preserving bottles. By means of the centrifuge and Rafter cell method of counting, an approximate idea of the food value in the different ponds of the Commonwealth, as interpreted by the more intensive work on the type ponds, could be obtained.

With a thorough knowledge of the natural conditions in all the ponds and streams in the Commonwealth, the Department of Fisheries and Game, in the future, will be in a position to properly stock the inland waters to the best advantage, and bring them to the state of maximum productivity. On this basis the work can be carried out with the greatest efficiency and economy to the benefit of every citizen of the Commonwealth.

SIMPLE CONVERSION RULES

To change centigrade to Fahrenheit: Multiply the number of degrees centigrade by 2; substract 10 per cent, and add 32.

For example, to reduce 100 degrees centigrade to the Fahrenheit scale, multiply the 100 by 2, making 200; subtract 10 per cent, leaving 180, and add 32, making 212.

To reduce meters to feet: Multiply the number of meters by 3, add to this number 1/100 of itself, and to this add $\frac{1}{4}$ of the original number.

For instance, to reduce 100 meters to feet, multiply 100 by 3, making 300; add 1/100 of this number, which is 3, and to this add $\frac{1}{4}$ of 100, 25, making 328 feet.

A BEAUTIFUL DOORWAY

On the opposite page is presented a picture of a doorway of the palace of Varied Industries at the Panama-Pacific International Exposition. The inspiration of this work was the portal of the Santa Cruz Hospice at Toledo, Spain, a structure which furnishes one of the truest examples of the Spanish Renaissance. It was originally without color, while the reproduction is tinted with blues, reds and browns of the exposition color scheme in the decorative detail. The doorway is mysteriously fascinating in its power to arrest the attention of the visitor.

The General Board of the Navy has calculated that the largest ship that could be built for transit through the Panama Canal would cost $20,000,000 and would be of these dimensions: Length 750 feet, beam 100 feet, draught 28 feet 6 inches, displacement 38,000 tons, speed 23 knots. The largest battleship in our navy at present is 544 feet long, with a tonnage of 26,000.

Doorway in the Palace of Varied Industries, Panama-Pacific Exposition

THE FUNCTION OF ENZYMES

PRODUCTS OF LIVING CELLS THAT AFFECT THE CHEMICAL OPERATIONS OF LIVING MATTER BUT DO NOT BECOME A PART OF THE FINAL REACTION

BY SAMUEL C. PRESCOTT

The study of the chemical or physiological activity of cells, whether of microbes or of men, is at once one of the most interesting and one of the most difficult problems of the biologist, for it seeks to disclose the secrets of life processes. How does a disease germ produce its poison, or a yeast cell bring about its characteristic fermentation? How do we carry on those transformations of food material by which beefsteak and bread and butter at once become available sources of energy and matter for our living machine? How does a potato manufacture starch in its leaves, transfer it to the growing tubers and there store it up for future use?

In each case by means of enzymes, which we may define as the tools of cells and the reagents by which the chemical reactions of cells of all kinds are effected.

The term "ferments" was first used early in the nineteenth century by Schwann and Berzelius. Afterwards the word was used somewhat indiscriminately, meaning either a micro-organism of fermentation or a chemical substance which in some way was related to living cells. To distinguish between these, the physiologist Kühne suggested the term "enzyme" to designate the digestive ferments such as pepsin, trypsin, and ptyalin. The word has now been universally accepted as the name of a group of chemical bodies, products of living cells, which have the peculiar property of effecting the chemical operations of living matter but which do not enter into the final products of these reactions.

Chemistry cannot produce enzymes, for they are found only as the products of protoplasm of living cells, and it makes no difference whether we are dealing with the ultra-microscopic bacterium or the giant redwood or the whale, the chemical activities are due to enzymes. Furthermore, the same kind of enzyme may be produced by organisms of widely different character, as for example, the trypsin of certain bacteria, of the carnivorous plants like the Venus Fly Trap, and of the human intestinal tract.

Since the variety of chemical processes carried out by living cells is large in number, it follows that the number of enzymes is legion. Even the number produced by a minute bacterial cell hardly visible with a high power of the microscope may be several, while with organisms of highly specialized form and physiological division of labor the number is greatly increased. In man, at least fourteen are known to be developed in the alimentary canal, and to take part in the process of digestion, while, if we added all the other chemical changes which may be elaborated in the body as a whole, our catalogue would be greatly increased. Moreover, we may assume that there are many enzymes which are still unknown, for the enzymes may be intra-cellular, that is, acting only within the cell as well as extra-cellular, or extruded outside the cell and so possibly capable of detection. The positive knowledge of the action of intra-cellular enzymes is still very meagre, although when Büchner discovered zymase and a method for its preparation in 1897, the first great step forward in their study was made.

What an enzyme really is, cannot be exactly stated. An enzyme is known only by its reactions. "By their works ye shall know them," is essentially true in the ferment world. We cannot even tell their composition or to what class of chemical substances they belong for they

have never been obtained in pure condition. It is generally assumed, however, without proof, that enzymes are protein-like in character. In spite of this indefiniteness and the elusive character of these bodies, certain general properties regarding them have become known and on these points all enzymes behave in like manner, although differing distinctly from other chemical substances.

We may thus regard enzymes as forming a special and peculiar group of chemical compounds, differing in certain ways from other substances, and especially in their relation to the law of mass action as shown by the great disproportion between the amount of the active substance and the amount of material changed. A good example of this is rennet which it has been stated can coagulate from 500,000 to 800,000 times its weight of casein, without being used up. All enzymes possess the same characteristic but not necessarily in the same degree. The activity is largely dependent upon the physical and chemical conditions of the environment. Thus very slight changes in the reaction of the medium on which an enzyme is acting may control very largely its power, or make the difference between high efficiency and practical inactivity. Some enzymes require neutral solutions for action, others are most vigorous in slightly acid or slightly alkaline media.

Similarly, temperature may play a very important part in the control of enzyme reactions. In this respect, these substances behave closely like living cells and like certain kinds of proteins. Each enzyme has a maximum, a minimum and an optimum temperature of activity, just as microbes have, and like these, if heated above the maximum, will be rendered inactive and finally destroyed. This thermal death point, as it may be called, is very near the coagulating point of albumin and not far from the death point of most vegetative bacteria. Another similarity to the proteins lies in the fact that both enzymes and albumins are precipitated by concentrated salt solutions such as ammonium sulphate, by alcohol and by salts of heavy metals. Furthermore, they may be more or less completely mechanically precipitated with flocculent or bulky precipitates, as by use of phosphoric acid and lime water. Certain poisons may also inactivate enzymes. Substances which kill living cells, like formaldehyde, hydrocyanic acid or mercuric chloride will in general "kill" enzymes providing the solutions used are strong enough and sufficient time is allowed for the destructive action. The enzyme has a somewhat greater resistance than has the living cell, but the difference is one of degree rather than of kind. In fact so closely do enzymes correspond to micro-organisms in behavior toward physical agencies, poisons, etc., that we use the same terminology in discussing them and speak of the "poisoning" or "killing" of the enzyme. Other substances, such as toluene, chloroform, and a few others, permit enzyme reaction but restrain the activity of living cells, this giving a differentiation of great value in studying them.

Enzymes also have many properties in common with the *toxins*, and, so far as body reactions go, seem to belong to the same class of organic compounds. When a toxin is injected in small amount into the body, certain chemical changes are set up, and there is soon formed a so-called antitoxin which neutralizes or inactivates the toxin. Similarly, the action of enzymes upon the tissues of the living body is effected by the secretion of anti-enzymes, and the injection of foreign proteins into the body may be followed by the manufacture of a "precipitin" which will precipitate that particular protein and no other. This specific action is characteristic of enzymes and toxins as well as of proteins. In view of the fact that enzymes and toxins are, like proteins, the products of living cells, it may not be strange that this similarity is found. However, we are not able to say that enzymes are protein in character but rather that they are found in association with proteins. The purest enzymes yet prepared do not give protein reactions. Moreover, mineral salts seem essential for their action.

We may explain the mechanism of fermentation and putrefaction changes on the basis of the enzymes produced by the inciting organisms, for in recent years it has been shown that the enzymes, carefully prepared and fed from living cells, will carry on the same changes with almost mathematical precision. In yeast, for example, Büchner found within the cells an enzyme which could only be extracted by grinding with fine sand and subjecting to enormous pressure, but which, when thus obtained, produced alcohol and carbon dioxide from sugar in exact accordance to the chemical equation which had long been used to represent the fermentation. Thus it was shown that intracellular enzymes exist, and we now believe that many processes taking place in living cells—perhaps all the processes—are the results of enzym activity.

Since the chemical nature of enzymes is so largely unknown, we can classify them only by their action on various compounds. It is possible, however, to group them into the four classes of *hydrolyzing*, or causing the addition of water to certain substances. Most enzymes acting on carbohydrates are of this class. So also are those that affect fats, and the majority of those producing known proteolytic changes. These are best represented in the processes of digestion. A second group are the *Zymase*, or those producing the splitting of bodies into simpler cleavage products without any hydration. The alcoholic fermentation is the best known of this class.

The remaining two classes are the *oxidizing* and *reducing* enzymes, producing the types of change implied. Of the former, the production of vinegar is a familiar example, alcohol being oxidized to acetic acid by an *oxidase* produced by the acetic bacteria. Such familiar changes as the darkening of freshly cut surfaces of fruits (apples) or the quick change of color when mushrooms and toadstools are broken, also belong to this category. The reduction processes are of enormous variety in nature, both in plant and animal life. While typically distinguished by the reduction of hydrogen peroxide to water and oxygen, these Katalases, as they are called, may also reduce sulphates, nitrates and various coloring matters as well as other compounds. Upon the activity of enzymes may depend all the complex series of changes, oxidations, reductions, synthetic and analytic changes which characterize the processes of growth and decay, renovation and destruction in the cell and in tissues. The phenomenon on intra-cellular fermentation seems to be closely linked with enzymic activity, and the building up and breaking down of protoplasm itself is intimately connected with intra-cellular changes and energy liberation.

There is reason to believe that some enzym actions are like organic chemical reactions, reversible. Thus, maltase will split maltose into two moleculars of dextrose under the ordinary conditions of action. If, however, we add maltase to concentrated dextrose solutions a small amount of maltose (or isomaltose, a similar sugar) will be formed, the reaction proceeding until a certain equilibrium is established. This has not been demonstrated for all enzymes, and some eminent authorities divide enzymes into two classes, only one of which is catalytic and capable of synthesizing as well as splitting substances, while in the other no trace of synthesis has been observed.

On the subject of the origin of enzymes and the causes stimulating their activity, many interesting observations have been made. Some enzymes are produced by cells in such form as to require no further aid to render them active. Others require the presence of a specific substance known as an activator. The pepsin of the stomach is produced by the cells of the gastric glands as a zymogen called pepsinogen, which, under the influence of the hydrochloric acid produced at the time the stomach is functioning, becomes changed to pepsin. We do not know how the enzyme and the acid are associated but we know that the latter is necessary for the production of pepsin and also for its action. Bayliss has described another instance in which the activator itself, enterokinase, acts as an enzyme upon the

zymogen, trypsinogen, thus producing trysin, but without entering into the actual formation of the finished enzyme—trypsin. If this view is correct, we have, in effect, one enzyme bringing a second into existence. In other instances, activation is effected by metals, as in the laccase, the oxidizing enzyme of the lac tree of Asia, which requires manganese; or by salts, such as phosphates, as in certain alcoholic fermentations.

In spite of the apparent lack of exact knowledge of the composition of enzymes and of all their activities, we find in this group of substances agents which are of direct and certain application to industrial processes. Breadmaking, brewing, cheese-making, certain phases of tanning, as well as the preparation of lacquers and castor oil, are a few of these applications.

Here is a field of great promise and infinite interest, sure to yield results if investigated patiently and consistently by the scientist who combines a deep knowledge of organic chemistry with an intimate acquaintance with cell behavior and activity, and this field of bio-chemistry is sure to find greater favor in the immediate future.

CASEIN PRODUCED ELECTRICALLY

Consul Hunt, stationed at St. Étienne, France, reports that casein, the principal albuminoid matter of milk, is now obtained by electrolysis. The milk is heated to 80 degrees centigrade in a large vat, in which is placed a porous vessel containing a 5 per cent solution of caustic soda; an iron cathode is placed in the soda, and carbon rod serves as an anode in the milk. Upon sending through an electric current, the phosphoric acid in the milk is set free and casein is precipitated. This is much cheaper than the old method of precipitating casein by the use of acids or rennet. Vegetable casein is now being produced from the soya bean, and it is said that this material can be put to the same purposes as animal casein. Casein is now largely used as a substitute for ivory, tortoise shell, celluloid, etc.

THE DURABLE FLEA

It is said that the flea, no matter what family name he may bear, is the most durable insect extant. The commoner kinds will recover after being soaked in absolute alcohol until they are completely paralyzed. In some experiments it was found that it takes 100 per cent. phenol more than one minute to kill one of these insects. Water has no apparent detrimental effect, neither has glycerine; and alcohol is inefficient. Formalin, phenol, mercuric chloride and trekesol in the strength used as disinfectants are of little value, and powdered sulphur none. Kerosene and miscible oil were found to be efficient. Bisulphide of carbon, hydrocyanic acid gas and sulphur dioxide were found to be highly efficient in the strength employed for flea destruction. It is, however, a fact that soap and water will put an end to any flea. If dropped in a tincture of green soap, he will live but about two minutes.

FUEL OIL FOR THE NAVY

It is interesting to note that the consumption of fuel oil in the navy is increasing very rapidly, and although but a portion of the fleet is equipped to burn this fuel, about 30,000,000 gallons are used per year. It is estimated that the time will soon come when the fleet will require 125,000,000, and a special board is investigating available oil lands with reference to future supply for the navy. Fuel oil stations will be established at convenient ports.

SOCIETY OF ARTS REPRESENTED

Prof. William T. Sedgwick, head of the Department of Biology and Public Health at the Massachusetts Institute of Technology, has sailed for Europe, and will represent the Society of Arts at the thirtieth anniversary of the Circolo Matematico of Palmero. The occasion is to be an important one at the great Sicilian University in that city, and it is proposed to celebrate by presenting a gold medal to the founder of the Circolo, Dr. Giovanni B. Guccia.

ADVANCES IN THE STUDY OF STORMS

RECENT EXPLORATION OF THE UPPER AIR THAT HAS SHOWN THE DUAL CHARACTER OF THE ATMOSPHERE AND OPENED A DOOR TO IMPORTANT DISCOVERIES

BY ALEXANDER G. McADIE

America has contributed its full quota of distinguished names to the science of Aërology, the new name for the older Meteorology; Ferrel, Maury, Espy, Redfield, Lapham and others, not omitting Thomas Jefferson and Benjamin Franklin. The late Lawrence Rotch, with his friend and fellow investigator, the late Teisserenc de Bort, may rightly be given credit for having inaugurated that campaign of upper air exploration which has resulted in the prime discovery of the dual character of the atmosphere, *i. e.*, the troposphere and stratosphere; and the further discoveries of variation in height of the bottom of the isothermal layer with season and latitude.

212° A. (−61° C.) at 13,040 meters, while the balloon was rising, or 213° A. by the other thermometer (Kleinschmidt) at 12,600 meters, while the balloon was descending.

The skeleton table on this page may be interesting.

Note that the pressure is given in kilobars. We shall return to this later; for the present it is enough to say that the megabar or *absolute atmosphere* is the pressure represented by 1000 kilobars or the force of 1,000,000 dynes. Note also that the temperature is given on the Absolute scale; and that the general practice now is to omit the 2. Thus the lowest temperature experienced by Scott,

Time	Pressure Kb	Pressure mm	Elevation Met.	Temperature Abs.	Gradient F/100 m	R. H.
7:00	1,001	751	100	290°	....	81
7:05 (?)	900	675	1,000	287	....	..
....	797	598	2,000	281	.056	..
....	705	529	3,000	275	.066	51
7:18	621	466	4,000	269	.042	34
7:20 (?)	547	410	5,000	264	.069	..
....	479	359	6,000	251	.086	30
7:34	313	235	9,000	234	.084	30
7:38	271	203	10,900	222	.065	..
7:44	199	149	12,000	216	.039	29
7:47:04[1]	168	126	13,040	213	.021	29
7:48	160	120	13,340	213	—.007	29
7:52	129	97	14,650	218	—.031	30
7:56	103	78	16,050	223	—.07	29
8:02	72	54	18,370	218	.01	29
8:12	36	27	22,720	222	.00	29
8:32	8	6	32,430	234	....	29

[1] Beginning of inversion.

Numerous records of soundings have been published by the International Commission for Scientific Aërostation. We give one of the latest records made at the observatory at Uccle, Belgium, June 9, 1911, during pleasant weather. A height of 31,780 d. meters (32,430 meters) was reached. The lowest temperature was given by one thermometer (Hergesell) as 213° A. (−77° F.) would be written 13° A., it being understood that the 2 precedes. It may also be well at this point to give some of the highest elevations made or deepest aërial soundings. At Pavia, Italy, 37.6 kilometers (23.4 miles) at Uccle, Belgium 33 kilometers (20.15 miles). The American record is 17 kilometers (10.5 miles).

Blue Hill Meterological Observatory

In recent ascents made at Batavia, Java, December, 1913, during the rainy season, a height of 26 kilometers (16.2 miles) was reached. Perhaps the best idea of the temperature fall for different months can be obtained from W. H. Dines in his table on Geophysical Memoirs 2.

It is evident that the mean annual isotherm of 273° A., *i. e.*, freezing, which reaches at sea level in latitude 62° N. and S. is at the equator more than 5 km. (3 miles) high; also that above the equator the fall in temperature continues to a much greater height than in temperate

Kilometers	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
14	216	17	19	21	22	23	22	21	19	17	16	15
13	16	17	19	21	22	23	22	21	19	18	17	16
12	17	18	19	·20	21	22	22	21	21	19	18	17
11	17	17	17	19	20	21	22	22	21	20	19	18
10	20	20	20	22	24	25	26	26	26	24	23	21
9	24	23	24	26	29	31	34	33	33	31	28	25
8	30	29	30	32	36	38	41	41	41	38	35	32
7	37	36	37	39	42	45	47	48	47	45	41	38
6	43	43	44	46	49	52	55	55	54	51	49	45
5	50	49	50	52	56	59	61	62	61	58	55	52
4	57	56	57	59	62	65	67	68	67	64	61	58
3	63	62	63	65	68	71	73	74	73	70	67	64
2	67	66	67	70	73	76	78	79	78	75	72	69
1	71	71	73	76	79	82	83	83	81	79	75	72
Ground	276	76	77	82	85	88	89	89	86	83	80	77

These values are for the British Isles. A more comprehensive arrangement is that of G. Nadler in a recent number of the *Beiträge der frein Atmosphäre.*

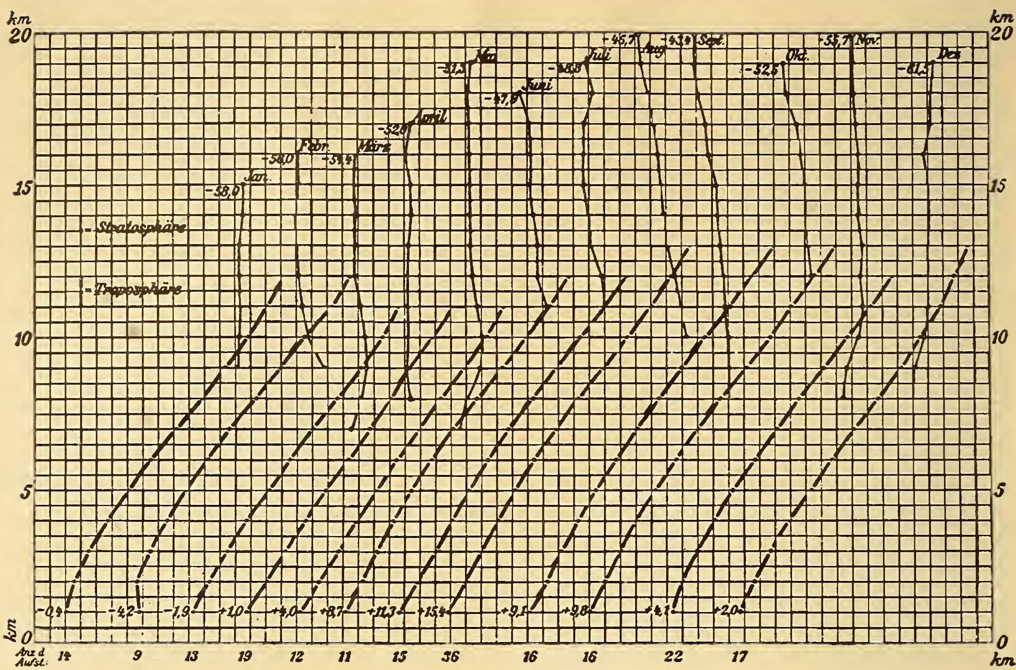
Cirro—cumuli

Cirrus—Ventosus (Windy Cirrus)

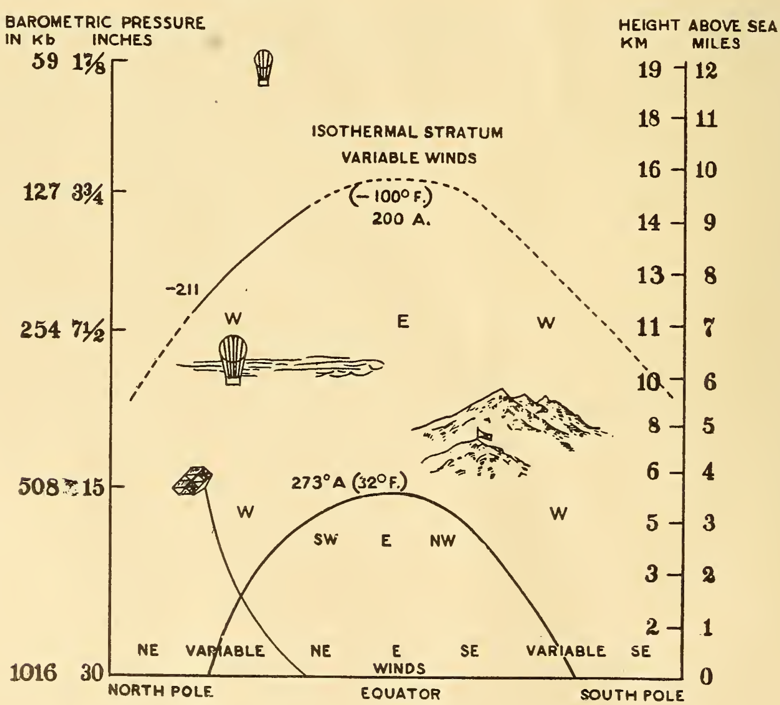
Whirling Cirro—stratus

regions; furthermore, that the lowest temperatures of the upper air are found above the equator. The work of Teisserenc de Bort and Rotch, beginning in 1905 with their well-known exploration of the air over the north tropical Atlantic, demonstrated that above the trades there was a change of wind direction, *i. e.*, above the northeast trade to southwest and above the southeast trade to northwest, the height of the plane of reversal varying greatly, while near the equator the wind was east at all heights. This has been strikingly confirmed by the recent Batavia, Java, records, when two sounding balloons entered the stratosphere at 17 km. (10.6 miles). On December 4, 1913, a temperature of 182° A. (−131.6° F.) was recorded. The balloon reached a height of 26 km. (16.2 miles) but from 17 km. upward there was a rise from 182° A. to 226° A. Now the average height of the stratosphere is 9.5 km. With a certain distribution of the water vapor, we find that this corresponds with a pressure of 250 kilobars, *i. e.*, practically three-quarters of the atmosphere is below this limit and in this radiation results in cooling while above the effect is a moderate heating. The minimum radiation temperature is approximately 214° A. or nearly the same as the lowest temperature experienced by Scott 213° A. (−77° F.). The temperature in the troposphere in equatorial regions may then fall 32 degrees lower than in temperate latitudes. Braak and others think that this may be explained by the pronounced vertical convection currents known to exist: and the different water vapor distribution.

In 1911, W. H. Dines, who has done so much experimental work, studying the relations between change of pressure at the 9 k. level and corresponding changes at the surface, advanced the view that inasmuch as the pressure variations were of the same order of magnitude, the



The figures beneath the diagram (*Anz. d.* and *Aufst.*) indicate the number of soundings upon which each monthly curve is based. The figures at the right and left express the altitude in kilometers, and those on the diagram itself, the temperatures in degrees C. For example, 15 sounding balloon ascensions in July gave average temperature of 284°A. (+11°C.) +11°C. at altitude one kilometer. The temperature decreased up to altitude 12 kilometers, and then remained almost constant, or increased slightly to altitude 19 kilometers, temperature 224°A. (−49°C.). And one readily sees that the beginning of the height of the isothermal region varies with the season. Fig. 2, drawn by Professor Rotch, gives the distribution of temperature over the globe, so far as known.



proximate cause of variation might be looked for at the level mentioned. It is the layer of maximum wind velocity just under the stratosphere and level near which is the most rapid change of temperature slope. In essence, a cyclone is produced by the withdrawal laterally of the air at 8–10 kms.

Shaw in his "Principia Atmospherica" (*Proceedings* Roy. Soc. Edinburgh, December 1, 1913), carries further the discussion of the relations of pressure and temperature in the upper air. In the stratosphere from 11 k. upward it is colder in the high pressure than in the low pressure at the same level; and in the troposphere from 9 k. downward it is warmer in the high pressure than in the low at the same level. He gives five laws which are briefly these:

1. Relation of motion to pressure.
2. Computation according to gaseous laws, especially $p = R\theta\rho$.
3. Convection.
4. Limit of Convection.
5. Saturation.

The postulates are

A. As given above, namely that in the stratosphere from 11 k. upward it is colder in the high than in the low; and from 9 downward it is warmer in the high than in low at same level and

B. The average horizontal circulation in the Northern hemisphere in January, between 4 k. and 8 k. consists of a figure-of-eight orbit from west to east along isobars round the pole with lobes over the continents and bights over the oceans.

The average circulation at the surface is the resultant of the circulation at 4 k. combined with a circulation in the opposite direction of similar shape, due to the distribution of temperature near the surface.

"SEASONING" CAST IRON

In the manufacture of the higher types of machinery, care is taken to lessen the cooling stress of iron castings by annealing or some other means, in order to make the iron homogeneous and less liable to breakage or distortion. This process is known as "seasoning." It has been found that in the case of ordinary test bars one inch square in section that there was a gain in strength of about 20 per cent. due to the shocks sustained during an hour in a tumbling barrel as compared with companion bars from the same ladle, not so treated. This phenomenon has become recognized and the American Society for Testing of Materials has revised its specifications for iron castings prohibiting the tumbling of test bars prior to testing. In the case of castings that cannot be well annealed by heating, an effect of softening may be secured by tumbling them while cool, or otherwise subjecting them to shocks, thus accelerating the removal of internal stresses by molecular movement. It is interesting to note that castings improve with age, owing to the slow or gradual escape of cooling stresses due to rearrangement of the molecules.

A GAS ENGINE SILENCER

Hiram Percy Maxim, inventor of the silencer for rifles, has produced a silencer for muffling other gaseous reports with special view to the silencing of the noisy exhaust of the gas engine. The device consists of a nested series of spiral cells between which are formed spiral whirl chambers which the exhaust must traverse. The silencing effect is increased by alternating the direction of the spiral whirl chambers so that the gases must travel alternately in a right-handed and in a left-handed direction. These chambers are larger as the opening is approached, to permit the gases to expand.

One of the particularly useful features of aeroplane reconnaissance is the fact that in looking down on a body of water from a great height, it is possible to see, plainly, objects at a considerable distance under water. The air-scout can not only see all the mines in a harbor with perfect distinctness, but they can easily be photographed from the aeroplane.

COLD LIGHT

An efficient cold or ideal light is far from being obtained commercially. Considerable progress, however, has been made in recent years toward this goal, and we anticipate still further progress in the near future.

The best method of comparing the efficiency of electric lamps is by comparing the light they give per unit of energy input, that is their lumens per watt, the lumen being the quantity of light which passes through a unit solid angle, emitted from a point source of one candle power intensity.

The maximum possible specific luminous output has been determined by several experimenters, but there is considerable variation in the values found. Drysdale and Nutting found the value to be around 200 lumens per watt, while Ives has calculated it as between 600 and 900, with the probability of 800 being the best value. These values are for that color light (yellow green of wave-length approximately 0.550μ) for which the eye has the greatest sensibility. A change in the color of the light makes a big difference in the luminous efficiency. For instance red light (.68μ) has a relative luminous efficiency when compared to yellow green light of only 2.6 per cent; yellow light (.59μ) 76 per cent; green light (.53μ) 91 per cent; blue light (.49μ) 23 per cent and purple light (.44μ) 2.9 per cent.

The following table shows approximately the relative luminous efficiencies of a number of our artificial lights.

These per cent luminous efficiency values are based on Ives determination of 800 lumens per watt as being the highest efficiency attainable.

Light Source	Spherical candle-power per watt	Lumens per watt	Per cent luminous efficiency
Hefner lamp			0.092 to 0.18
Carbon filament, 3.1 watts per candle	0.26	3.3	.4
Gem filament, 2.5 watts per candle	0.32	4.0	.5
Tantalum filament, 2.0 watts per candle	0.4	5.0	.6
Nernst Lamp	0.50	6.3	.8
Osmium filament	0.56	7.0	.9
Moore vacuum tube	.63	7.8	1.0
Tungsten filament, 1.1 watts per candle	0.73	9.1	1.14
Gas Filled Mazda lamp	1.2	15.0	1.9
Neon tube	1.4	17.5	2.2
Carbon arc, enclosed 6.6 amp.	0.4	5.0	.6
Magnetite arc—6 amp.	1.3	16.4	2.1
White flame arc—10 amp.	1.8	22.9	2.9
Firefly			96.5
Yellow green light, 0.545 μ wave length	65.	800.	100.

If the light source is an incandescent body, the maximum radiant efficiency possible to obtain would be when the body is between 6000° and 7000° abs., the radiant efficiency being the ratio of the energy radiated as light to the total radiated energy. Even then its efficiency is only about 50 per cent. At temperatures above 7000°, the maximum wave length moves from the yellow green toward the ultra-violet, the relative luminous efficiency consequently being much less. We must therefore turn to other sources, such as luminescent phenomena, which give off light without production of a large amount of heat, and which radiate selectively in the visible spectrum, for the true ideal light.

There is a large amount of work being carried out on fluorescent and phosphorescent materials, some of which (especially the latter) may give us an efficient luminous radiator.

Electro-luminescence, examples of which are the Moore tube and the Claude Neon lamp, already is being used commercially, although at present it is not extremely efficient.

In certain instances chemical action is accompanied with a production of light. The amount, however, is always so small that not much is expected along this line in the future.

Finally there is the light given off by certain bacteria, worms, fire-flies, etc. This latter comes nearest being the true cold light, and is what scientists are striving to duplicate.

R. C. ROBINSON.

SOCIOLOG AL WORK IN FA TORIES

WITH the evolution (welfare and safety provisions on the part of corporations running model plan s, a new force has entered industrial life. Not only is the condition of the workingman being appreciably bettered, but the manufacturers themselves find that they are making a distinct gain, sometimes in actual economy, and always in the contented service of their workmen which results.

The Welsbach Company, in its different plants, has established many safety measures, thereby minimizing its money obligations for accident. In their factories, gears, saws, belts, punch presses, knives and shears are covered. Grinding wheels are encased. For the general protection of health, buffers have the dust exhausted by suction fans, and workers are supplied with face hoods provided with wet sponges for the nose. Noxious acids are carried off by exhaust hoods; mantels, after collodionizing, are dried in closed chambers which carry downward vapors of wood alcohol and ether; blue glass plates are in use to protect the eyes from the intense glare occasioned by the hardening of the mantles. As the hardening rooms are excessively hot, and the processes of burning and hardening vitiate the air, they are supplied with fans to bring in cool air. Some of these fans supply fresh air to individuals as they work at their machines.

The company supports a hospital on its own premises with a nurse and a salaried doctor. It also keeps a limousine and an open car to carry accident cases to the hospital. All medical attendance and medicines are supplied employees gratis. The company goes a step farther and examines its men to ascertain their physical fitness for any work which subjects them to exceptional danger.

Considerable attempt has been made to beautify the grounds with shrubs and flowers, and to supply the employees, both men and women, with comfortable lunch rooms where good food is sold very cheaply, and with rooms where they may enjoy the privileges and comforts of club life. The young women have a piano in their club rooms; the men have a tennis court nearby. The women employees are now given five minutes for fresh air and relaxation twice a day. The cost of these recesses to the company has been estimated to be $2000 a year; but the result is actual gain owing to the refreshed vigor with which they continue exacting tasks.

Similar welfare work is carried on by a trained worker at the plants of the New Jersey Zinc Company. This company began its experiment in a small way with a Neighborhood House and Kindergarten. This Neighborhood House has since been enlarged. Classes of many kinds are held there, including such a range as folk dancing, hand work, and classes for foreigners' English. In this last class adult foreigners are taught technical terms which they need to know to carry on their work and to avoid accident, lessons in preventing accident to themselves, and the first aid to the injured. Here also they are encouraged to look forward to owning their own homes. Books, in several languages, and magazines are freely distributed. A gymnasium is maintained, and dancing under pleasant, wholesome conditions is encouraged, so that it is highly improbable that the cheap, commercial dance hall, with all its objectionable features, would appeal to the employees of this company who every Saturday night congregate for dancing in the Neighborhood House, often to the number of six hundred. The company moreover carries on a bank and two co-operative societies. The New Jersey Zinc Company does not intend that its welfare work shall offset good wages; it does claim that corporations doing welfare work do not fall below the scale. It also believes that the wage that is a fair one from the point of view of the value of a workman to his employer is not large enough to keep him and his family in anything more than the necessities of life. Books for his children, and suitable recreation, he cannot provide. The company considers that the body of

employees, who represent the composite labor of the corporation, should have, not as charity but as justice in business methods, the best it can afford to give them. E. T. S.

THE SMOKE NUISANCE

Agitation for the abolishment of the smoke nuisance usually meets with opposition from the manufacturers who object on the ground that it would add to their expense to introduce smoke consuming devices. In view of the numerous anti-smoke crusades now going on, the following figures compiled by the University of Illinois Engineering Experiment Station may be of interest. A so-called "smokeless boiler" was used and the tests showed that the density of the smoke emitted was well within the limits of the strictest ordinance likely to be passed. The tests of efficiency were made with six different coals and each was tried in both the smokeless and the regular type of boiler. The detailed results of the test follows:

	Smokeless efficiency per cent.	Regular efficiency per cent.
With Iowa slack	47.1	39.5
Iowa slack	57.9	43.3
Illinois mine run	59.3	48.5
Illinois nut	67.0	56.1
Illinois lump	74.3	65.2
Pocahontas	74.9	57.2

TESTING PURITY OF SUGAR

A quick way of determining the purity of maple sugar, which has recently been put into practical use, depends upon the difference in electrical resistance of impure and pure sugar.

Standards of resistance were determined by sending a current through a solution of pure sugar, and then by making similar tests with sugar adulterated by the ordinary methods. It is not only a simple matter to determine whether the sugar is or is not adulterated, but the form of adulterant is also usually indicated by the degree of resistance.

RISK OF DEATH ON RAILROADS

It has been computed that the average railway journey in the United States is thirty-four miles in length; and based on the number of fatal accidents, it is stated that a passenger might take 2,275,122 such journeys with only one chance of being killed. At two trips per day this would require 3,792 years. If, for instance, the fatal accident should happen on the last day of the period, it would have been necessary for the traveler to start his program, of two trips per day, in the year 1879 B. C.

SCIENCE CONSPECTUS

VOL. IV 1914 NO. 4

RECENT ACHIEVEMENTS OF CHEMISTRY

A BRIEF SUMMARY OF NOTABLE DISCOVERIES AND DEVELOPMENTS IN THE FIELD OF CHEMICAL INDUSTRY—SYNTHETIC PROCESSES THAT ARE SIMULATING NATURE

AT THE Eighth International Congress of Applied Chemistry, Dr. Carl Duisberg of Eberfeld, Germany, read a notable paper on the latest achievements and problems of the chemical industry. Dr. Duisberg briefly covered the entire field of chemical endeavor, and from his address the following instructive excerpts have been taken:

Probably in no domain of human knowledge and endeavor have the combined forces of theory and practice, intimately acting and reacting upon each other, made such immense strides and led to the solution of such difficult problems as in the chemical industry, an industry which, indeed, had its beginnings in the distant past, but in its vast development and international character is essentially a child of modern times. Success has so emboldened this industry that it considers itself capable of solving any problem, provided the men in its service are well trained in theory and practice and ready to devote themselves to the best of their ability, with patience and perseverance, to the object in view. This has been shown by the struggle between the contact process of producing sulphuric acid and the old "chamber process"; by the rivalry between the Solvay process and the Le Blanc method in the manufacture of soda; by the production of nitric acid and its salts by direct oxidation of nitrogen of the air under the influence of the heat of the electric discharge; by the manufacture of ammonia from atmospheric nitrogen indirectly via calcium cyanamide, and directly by combination with hydrogen; by the replacement of madder by alizarine, and of natural by synthetic indigo, as well as by innumerable other instances in the color, perfume, and pharmaceutical industries.

If, before an audience not wholly consisting of chemists, I venture, within the brief period of an hour, to describe the latest achievements of the chemical industry and to recount the problems that are engaging our attention, I must restrict myself to a great extent both in the choice of the subject matter and its mode of presentation. We can, indeed, merely touch upon the most important happening in our industry and must, from the very outset, refrain from a thorough discussion of the subject, either from the purely chemical or the technical side.

In the spirit of Faust, "Who brings much will bring something to many," I invite you to make a flight with me in an airship, as it were, over the fields where the chemical industry holds sway, and, from our point of vantage, to make a bird's-eye view of the latest achievements of this industry. Now and then

we shall make a landing and examine the most attractive features a little more closely.

PRODUCTION OF POWER

The question of power, which is of the utmost importance in every industry, and especially in the great synthetic processes, by means of which nitric acid and ammonia are manufactured, is now dominated by the perfected utilization of hydraulic power and the development of the turbine. Not only does the transmission of electric energy render it possible to utilize water power at great distances, but it also allows of the transmission of power evolved at the coal mines and the peat fields to distant points, thus eliminating the necessity of transporting the fuel itself. Recently we also learned to apply the principles of the water turbine to the steam turbines. But this advance over the piston steam engine, which Watt so ingeniously constructed about one hundred fifty years ago, has already been surpassed by benzine, petroleum, or oil motors (Diesel motors), and, above all, by the reliable gas engines which are driven by blast-furnace gases, Mond gas, and more recently by peat gas.

PRODUCTION OF BY-PRODUCTS

The manufacture of by-products goes hand in hand with this more direct generation of energy from fuel. These products include ammonium sulphate, of such great importance in agriculture, and the tar distillation products, so indispensable in the color industry. The latest and most rational method of utilizing the peat or turf beds, which are so plentiful in Germany and in many other countries, is practiced in Schweger Moor, near Osanbrück, according to a process discovered by Frank and Caro. There peat gas is produced and utilized and ammonia obtained as a by-product, the required power being generated in a 3,000-horsepower central electric power station. The moorland, after removal of the peat, is rendered serviceable for agricultural purposes.

At that place nearly 2,500 to 2,600 cubic meters of gas, with 1,000 to 1,300 calories of heat, were obtained from 1,000 kilograms of absolutely water-free peat in the form of air-dried peat, with 45 to 60 or 70 per cent, of moisture. This gas represents energy equal to 1,000 horsepower hours, equal to 700 kilowatt hours, after deducting the heat and power used for the operation of the gas works. In addition 35 kilograms of ammonium sulphate were produced from the above quantity of peat, which contains 1 per cent of nitrogen

PRODUCTION OF COLD

Besides the problem of power and heat, the question of refrigeration is one of growing importance to the chemical industry. Instead of the ammonia machines with which a temperature of minus 20° C. can be attained, we employ today sulphurous-acid machines, or, better still, resort to the carbonic-acid gasifier, which yields a temperature of 40° C. below zero. It is hoped in the near future to produce refrigerating machines which, by the use of suitable hydrocarbons, will give temperatures of minus 80° C. Plants for the liquefaction of air, producing as low a temperature as minus 190° C., are becoming more and more common, and are especially profitable where gas mixtures, rich in oxygen, or where pure nitrogen, which are simultaneously produced, can be utilized. Diagrams showing the process invented by Linde for the rectification of liquid air with the object of isolating nitrogen and oxygen are exhibited here. The Badische Anilin and Soda Fabrik in Ludwigshafen on the Rhine intends to manufacture hydrogen from water gas in a similar way and to utilize the carbon monoxide, which is simultaneously obtained, as a source of power. In a large plant which is being erected the firm is going to produce ammonia synthetically by combining, according to Haber's invention, pure nitrogen, obtained by the liquefaction and rectification of air, with hydrogen manufactured as above.

MATERIAL FOR CHEMICAL APPARATUS

As regards the material for chemical apparatus, several new wares must be referred to:

Quartz vessels.—Apart from the fact that the saltpeter industry of Norway taught us how to absorb dilute nitrous gases in towers 20 meters high, made of granite, a substance which was rarely used for chemical purposes, we have today at our disposal tubes, dishes, and vessels of fused quartz, which are stable against acids and heat and which are manufactured in the same sizes and dimensions as the well-known earthen vessels.

Refined steel.—The greatest progress, however, has been made in the manufacture of iron alloys or refined steel.

Thanks to the kindness of Friedr. Krupp of Essen, I am in the fortunate position to describe a large number of hitherto unknown substances of great importance, of which I exhibit magnificent specimens, photographs, and lantern slides. Just here, however, I must ask you to make one of the landings from the upper air and permit me to deal with the subject at greater length. You will be astonished at the immense progress which has been made to the general benefit of our industry.

Of the greatest interest are the alloys of iron with other heavy metals and metalloids, *i. e.*, alloyed steel.

Instead of carbon, other elements are employed, which likewise enhance the hardness of steel, but prevent the formation of a crystalline microstructure liable to cracks and flaws. The most important of these elements is nickel.

Nickel steel.—The readiness with which nickel forms an alloy with iron has long been common knowledge. Even in Bessemer's days attempts were made in Great Britain to turn out cannon made of steel containing 2 per cent. nickel. The experiments were not successful because the nickel obtained at that time contained impurities, such as copper, arsenic, and sulphur, so that the steel could not be forged. Thirty years later pure nickel, as we know it today, made successful results possible. The same was the case with chromium, silicon, and manganese, and not until these elements were produced pure could successful alloys be manufactured with them, either alone or together with nickel. The chief aim in the manufacture of these alloys is the formation of an amorphous pliable structure of the steel. This result is attained not only by removing more or less of carbon, but above all by a certain thermic treatment, heating again and keeping it at a certain lower temperature. You will see two samples of steel; in the one case, the coarse crystallization of the pure carbon steel before it is forged, and in the other, the same steel refined by the thermic treatment. The difference in the microstructure of the forged carbon steel and that of the forged and thermically treated nickel steel must also be noted. While carbon steel, after forging, still shows a crystalline structure with visible cleavage planes of the crystals, the section of nickel steel displays an amorphous structure closely resembling that of welded iron. For comparison sake, a sample of a welded iron fracture is exhibited. It must not be overlooked, however, that nickel and chrome nickel steels are twice or three times as hard as welded iron. There are also exhibited test pieces of construction parts to be used in the automobile industry made of alloyed steel. Notwithstanding the high tensile strength of about 90 kilos per square millimeter (*i. e.*, about 55 tons per square inch), no fracture is noticeable, although they are greatly bent.

Aside from these improvements, which are of such great moment for structural steel, the iron alloys have found many new applications.

I merely mention the different nickel alloys for shipbuilding, electric appliances, and for valves. These valuable alloys containing 23 per cent. and more nickel, are nonmagnetic, and not affected by atmospheric influences; those containing 30 per cent. nickel possess great resistance to electricity, whilst the coefficient of expansion of steel with 45 per cent. nickel is only one-twentieth of that of ordinary steel and not greater than that of glass.

Chromium, tungsten, and molybdenum steel.—It is a very interesting and novel fact that by the thermic treatment alone the microstructure of the cheaper kinds of unalloyed iron plates and iron shapes is

so changed that it becomes three times as resistant to the destructive effect of acids. If alloys of iron with chromium, tungsten, molybdenum, and aluminium in certain proportions are thermically treated, this resistance is increased fivefold, as is shown by samples of ordinary carbon steel and chrome nickel steel which underwent a treatment with dilute sulphuric acid for 56 days.

An alloy of ordinary iron with 5 per cent. nickel is an excellent material for withstanding hot caustic soda. Most astonishing properties are displayed by steel alloys containing more than 10 per cent. of chromium and a small addition (2 to 5 per cent.) of molybdenum. Such alloys are manufactured in the form of malleable cast and forged iron pieces by Krupp according to the patents of Borchers and Monnartz in Aix-la-Chapelle and in the form of rolled tubes by the Mannesmann Röhrenwerken in Remscheid. These alloys are insoluble not only in dilute hydrochloric acid and sulphuric acid, but also in dilute nitric acid, even with the addition of alkalichlorides, and if they contain about 60 per cent. chrome, 35 per cent. iron, and 2 to 3 per cent. molybdenum they withstand even boiling aqua regia. You will see samples of this extraordinary steel, after treatment with acids, compared with ordinary steel and cast iron.

Tool steel.—It must be especially mentioned that the alloys of iron with chromium, tungsten, and molybdenum tempered by a special process invented by two Americans—Taylor and White—find most important uses as quick turning steel for all kinds of tools.

Vanadium steel.—The most recent improvements in the manufacture of steel for tools which must of necessity keep pace in hardness with structural steel have been made by the employment of vanadium. Unfortunately, this metal, the use of which is steadily increasing, is still very dear, and the problem which chemists have to solve is to produce it more cheaply. If the price could be reduced perceptibly, metallurgists prophesy a great future for this metal, which exercises a very favorable influence on the microstructure of steel.

Of great importance are those alloys of iron with chromium, tungsten, and vanadium, which possess a high degree of hardness even at 400 to 500° C. They are needed by engineers for the construction of steam turbines, for the embossing and spraying of metal objects when heated to redness, a process which has lately found extensive application. Chemists use these kinds of steel whenever chemical reactions are carried out at high temperatures and pressure, *e. g.*, for the synthesis of ammonia according to Haber's process.

The very latest alloy has now been patented and is being manufactured by Krupp for the construction of safety vaults and safes. This steel can neither be drilled nor exploded, nor can it be cut by the oxyhydrogen flame.

Two samples of steel are exhibited, one of ordinary steel in which great holes have been cut in five and one-half minutes by using an oxyhydrogen flame and in six minutes by an oxyacetylene burner, and a specimen of this new alloy which has remained intact after being treated with the same oxyhydrogen and oxyacetylene flames for one and one-half hours. Let us hope that on this hard and infusible material the scientific safe burglar will exercise his noble art in vain.

Manganese steel.—Of the alloys made with manganese, the manganese steel or hard steel, first produced by Robert Hadfield, because of its great wear, is chiefly for cast-iron parts of disintegrators and rails of electric tramways. On account of its hardness, this steel is not malleable, but it can be bent in the cold state, and is thus very safe against breaking. It is therefore of much interest to the chemical industry where, in almost all branches, grinding operations are carried out.

Silicon steel.—Finally I wish to refer to alloys of iron and silicon which contain $1\frac{1}{2}$ to $2\frac{1}{2}$ per cent. silicon and a high percentage of carbon. This steel is excellently adapted for tools and springs which must stand high strain. Since steel alloys containing much silicon, although brittle and porous, have proved very stable against acids, they are now being used

more and more where such a property is of importance.

Alloys with about 4 per cent. silicon, but very poor in carbon, are of greater value than the above. Robert Hadfield first pointed out the importance of this alloy, whilst Krupp, working in connection with Capito and Klein, a firm of fine-plate rollers in the Rhineland, considerably improved it and introduced it for electric purposes. It is employed in large quantities in the form of sheets of 0.35 millimeter (1/70 inch) thickness for the construction of dynamos, alternate-current motors, and transformers. In Germany alone the consumption of this alloy already amounts to 8,000 tons a year. This material has a resistance to electricity four or five times greater than that of ordinary iron and loses only half as many watts, so that the injurious Foucault currents are reduced to a minimum. The manufacture of transformers has, therefore, become much cheaper, for the proportion between iron and copper is much more economical. The production of this silicon iron alloy, with its very low percentage of carbon, and that of the chrome nickel steels, almost free from carbon, became possible only after silicon and chrome, entirely free from carbon, could be manufactured by electric smelting processes.

Electro-steel.—Since the electric smelting furnace has come into use in the steel industry, the problem of removing the sulphur, which engaged the attention of chemists for so many years, has been solved. It has been found that the electric furnace process produces a slag free from metal, and such a slag is the prime requisite for the complete desulphering of the steel bath.

Electrolytic iron.—Superior to the silicon steel, poor in carbon, in its electric properties is the "Ideal" metal for electromagnets—the pure electrolytic iron—first produced by Franz Fischer, of Charlottenburg, and now manufactured by the firm Langbein-Pfanhauser & Company, Leipzig. Formerly it was impossible to produce it free from hydrogen, consequently it was hard and brittle and was not malleable. Only by electrolyzing at 100° to 120° C. and employing an iron salt solution mixed with hygroscopic salts, such as calcium chloride, the iron became free from hydrogen. Its hardness then sinks far below that of silver and gold and is not much greater than that of aluminium. It possesses the valuable property of becoming magnetic more quickly than ordinary iron, containing carbon or silicon, and also of again losing its magnetism more readily, thus considerably increasing the efficiency of electromotors, for which it is used. Amongst the exhibits you will find several objects made of this electrolytic iron; for example, a cathode made from an electrolytic iron plate during five days of uninterrupted operation; also plates made by rolling; further a motor which, if constructed of silicon iron, would furnish 0.5 horsepower, but being composed of electrolytic iron, though in use for several months without appreciable signs of war, it now furnishes 1.3 horsepower, in other words it is two and one-half times as efficient.*

With all these new materials at our disposal, among which I must also mention copper, with 10 per cent. silicon, and copper nickel, we shall surely be able to improve all sorts of chemical apparatus that suffer so much from wear and tear.

After this short invasion of the domain of metallurgy, we shall now turn our attention to the chemical industry proper, first dealing with the manufacture of inorganic substances, the heavy chemicals.

SULPHURIC ACID

The triumphal progress of the contact process for the manufacture of sulphuric acid in the United States scarcely has its parallel in Germany, where it originated. Platinum, in spite of the fact that its price has increased threefold, is still our principal contact agent. As it is possible to carry out other contact processes with various contact materials, we shall certainly find other agents than platinum available for sulphuric acid anhydride. It ought therefore to be a fruitful field for research to find cheap substitutes for platinum. The Americans, in the twenty

* See Zeitschrift für Electrochemie, No. 16, 1909.

years that have elapsed since Knietsch first successfully carried out the contact process, have increased their output threefold for the same weight of platinum. Nevertheless, the old lead-chamber process still competes with the new method, and the steady improvement of this process and the purity of the resulting acid must be acknowledged. In fact, the lead-chamber process promises to make further progress in the future in view of the success of Falding's high chambers and Opls towers, in which large quantities of acid flow down.

The Gaillard tower is supreme for concentration and recovery of the acid and for the regeneration of the various waste acids.

AMMONIUM SULPHATE

A new way of manufacturing sulphuric acid, together with ammonia, from the gases which are produced by the dry distillation of coal, is looming above the horizon. Burkheiser is seeking, with the aid of especially prepared wet iron compounds, to bind the sulphur, simultaneously absorbing cyan, and to convert the ammonium sulphite thus produced into ammonium sulphate by oxidation with atmospheric air.

In competition with Burkheiser, Walter Feld is endeavoring to recover sulphur directly as ammonium sulphate by a series of interesting reactions, in which thiosulphates play an important part. Such plants are in operation in Königsberg and here in New York.

NITROGEN COMPOUNDS

So much has been written concerning the progress made in the last five years in the utilization of atmospheric nitrogen that I need not enter into a description of Kirkeland-Eyde's, Schonherr's or Pauling's process for the direct oxidation of nitrogen by means of the electrical discharge, nor of Frank-Caro's method of forming cyanamide from carbides (the world production of cyanamide is, according to Dr. N. Caro, 120,000 tons per year, of which 31,000 tons are manufactured in Germany [16,000 in Trostberg and 15,000 in Knapsack near Cologne], 19,000 tons are made in Niagara Falls by the American Cyanamide Company, and during the next three years the total production is to be increased to 200,000 tons), nor is it necessary to describe the Serpek process for the production of ammonia from aluminium nitrides combined with the utilization of alumina which is simultaneously obtained. I will mention, however, that the problem of concentrating the dilute nitric acid, as obtained in the large absorption apparatus from nitrous gases, has been solved by Pauling's method, in which sulphuric acid is used in a battery of towers. It is also possible now to convert economically cyanamide into ammonia and this again into nitric acid.

SODA AND CHLORINE

The fifty-year-old Solvay process, which has conquered the whole world, still remains master of the situation. This is all the more remarkable since it is still imperfect as far as the yield is concerned, for a quarter of the salt used in the process is lost as such, and the whole amount of chlorine in the form of calcium chloride.

Although the materials employed in the Le Blanc process are completely utilized, this fact will not give it any chance of surviving, and it would seem to be now chiefly of historical interest.

Not less remarkable is the twenty-five years' career of the alkali-chloride electrolysis. The limited market for chlorine compounds and the great space taken up by the electrolyzing baths were great obstacles to the progress of this apparently so simple method. For the same reasons the most approved processes, such as the Grieshiem cement cell, the quicksilver cathodes of Castner and his successors, the Aussig Bell and the wire-gauze diaphragm of Hargreaves, with its many varieties, of which the Townsend cell is the latest and best, did not develop as expected. The limited demand also quickly restricted the operation of the brilliant method of manufacturing chlorates by electrolysis.

TIN

Tin is not only produced from natural ores but also in more than twenty detinning establishments from tin plate and

tin-can waste; 200,000 tons of tin-plate waste are subjected to this treatment and about 24,000,000 marks ($6,000,000) worth of tin and iron are recovered. The electrolytic detinning process, on account of high wages, the great cost of current, and the considerable manufacturing loss, has been replaced—where there is a market for chloride of tin—by the patented process of Thomas Goldschmidt, of Essen. This process takes advantage of the properties of chlorine gas, in the dry state, to greedily take up tin without reacting on iron if certain temperatures are observed. Instead of the inferior quality of electrolytic tin mud, which must be converted into marketable tin by costly smelting operations, the new process yields an anhydrous tin chloride, which is used in large quantities for weighting silk. The detinning with chlorine is not carried out with cuttings, as in the electrolytic process, but with waste pressed in hard packages, so that twenty times as much material can be treated in the apparatus at the same time. In the United States this process is operated by the Goldschmidt Detinning Company of New York.

REDUCING AND OXIDIZING AGENTS

One of the most brilliant successes in applied chemistry has been achieved by the perservering experiments of some chemists with a long-neglected substance, the constitution of which had never been properly understood. The old hydrosulphite of Schützenberger, rendered stable and easily transportable in powder form as an anhydrous sodium salt or as rongalite in combination with formaldehyde, has now become a most important article of commerce. It is chiefly used in vat dyeing and for reducing purposes in general, such as stripping dyed fabrics and as decrolin for bleaching sugar.

PEROXID OF HYDROGEN, PERSULPHATE, AND PERBORATES

Peroxid of hydrogen and its derivatives at present find less favor in commerce, although their future appears to be very brilliant. Recently the Farbenfabriken vorm. Friedr. Bayer & Company succeeded in rendering this important oxidizing agent, which easily decomposes and which can be marketed with difficulty only in watery solution, solid and stable by the addition of urea.

This powder is in the market under the name of ortizon, but on account of its relatively high cost it is intended not so much for technical as for hygienic and pharmaceutical purposes.

The interesting manufacture of sodium peroxid from sodium and the many scientific investigations of the persalts, have not been followed by great commercial success. The persulphate and perborate, however, the latter under the name of "Persil," are being manufactured on a large scale. The reason of this failure seems to be the high cost of production.

RARE METALS

The most interesting alloys discovered by Muthmann and Auer have found little application in the arts, and the use of cerium and thorium preparations is still confined to the incandescent gaslight industry. Only the "Auermetal," consisting of 35 per cent. iron and 65 per cent. cerium, is employed and this only to a limited extent for the manufacture of pocket cigar lighters.

In the metal filament lamp industry, tungsten, which shows the highest melting point of all metals, namely 3,100°, has replaced tantalum, which melts at about 2,300°. This became possible only after successful experiments to render the metal ductile by hammering.

The elements cadmium, selenium, and tellurium are obtained in great quantities as by-products; the first is produced in the zinc industry, the other two from the Tellur gold ores which are found in Cripple Creek, Colorado. Although they are sold at relatively low prices, they find but little use in the industries.

ARTIFICIAL PRECIOUS STONES

Finally, I will, in but a few words, touch upon a new industry, viz., the synthetic manufacture of precious stones from alumina with additions of chrome oxide, iron oxide, or titanic acid. Artificial rubies and white, yellow, and blue

sapphires, which cannot be distinguished from natural stones, are being manufactured in great quantities in Paris and recently also by the Electrochemische Werke, Bitterfeld. They are used extensively for jewelry and especially as bearings in watches and measuring instruments.

All this will give you a striking picture of the development of inorganic chemistry, which is taking a more and more important position beside organic chemistry.

SYNTHETIC PERFUMES

In the perfume industry, the developments made since the scent of the violet was imitated with jonon, and since the successful synthesis of camphor from turpentine, are not of such nature that we need to deal with them at great length. The importance of this industry appears from its yearly turnover of forty-five to fifty million marks (ten to twelve million dollars). Here the efforts of the chemists are directed toward determining the constitution of the complex and simple natural perfumes, isolating the various products of decomposition obtained during the investigation, and finally reproducing the natural perfumes synthetically. Such results have already been achieved in the case of the odor of the rose, lily of the valley, and violet. Very often certain substances are needed in the compounding of perfumes, which, like indole, possess anything but a pleasant smell.

ARTIFICIAL SILK

Even if doubt be expressed as to whether artificial silk (the yearly consumption of which amounts to about 7,000,000 kilograms) still belongs to the chemical industry because it stands in such close relation to the textile industry, with its weaving and spinning machines, yet the raw materials needed for its production, such as nitrocellulose, copper ammonia cellulose, and cellulose-xantogenate, are of such importance that the chemist and engineer equally divide the responsibility in this branch of manufacture. Viscose silk from xantogenate of cellulose, the production of which has been recently very much improved, seems to replace nitrocellulose silk and the copper ammonia silk. This viscose silk surpasses all other artificial silks in luster and is the cheapest to manufacture, so that the apparently simplest process of all, the copper ammonia cellulose silk, cannot compete with it any more. Among the exhibits are fine specimens of this silk from the Vereinigten Glanzstofffabriken of Eberfeld and their factory in Oberbruch in Dremmen near Aix-la-Chapelle, including the various raw materials, wood, cellulose, alkali cellulose, and the cellulose xantogenates produced by treatment with bisulphide of carbon and the viscose solution itself.

ACETYLCELLULOSE-CELLIT FILMS

From the acetylcellulose soluble in aceton, called cellit, the Farbenfabriken vorm. Friedr. Bayer & Company first produced cinematograph films, but although they have the great advantage over those manufactured from nitrocellulose in being noninflammable, it has not been possible to introduce them generally. In all their properties the cellit films are equal to the old inflammable ones, yet the proprietors of moving-picture theaters do not take them up because they fear the competition of the schools and the home where the cellit films would be largely used on account of their noninflammability. The only help then would be such action by those in authority as to make it difficult to employ inflammable films and to facilitate the use of cellit films. There are prospects of such legislation at least in Germany, which would put an end to cinematograph fires with their great danger to life and property.

NONINFLAMMABLE CELLULOID (CELLON)

The problem of manufacturing noninflammable celluloid by mixing cellit with suitable camphor substitutes which burn difficultly or not at all may be considered as definitely solved. Eichengrün has simplified the manufacture to an extraordinary extent by showing that certain acetylcelluloses may be gelatinized

in the same way as nitrocellulose. As is well known, nitrocellulose with camphor in the presence of a solvent yields a so-called solid solution, and even in the dried state may be easily cut or formed into sticks, tubes, or threads. Cellit, when treated in exactly the same way with appropriate camphor substitutes, can be converted into "cellon," the non-inflammable substitute for celluloid. Single blocks weighing 200 pounds are already produced on a large scale which like celluloid can be sawed, cut, and polished; when heated can be pressed or bent; and when subjected to steam at a high temperature can be drawn and molded. Compared with celluloid, cellon has the advantage of being more elastic, soft, and ductile. It is therefore frequently used as a substitute for hard rubber, gutta percha, leather, etc. Cellon, in the form of a highly viscous, siruplike solution, may be employed for coating fabrics, wood, paper, metal, etc., with a thick, enamel-like, uniform and pliable surface. Thus patent leather, artificial leather, insulators, balloon covers, etc., may be produced. In France this varnish is already employed for enameling aeroplanes. Objects made of this novel and widely useful material are to be found among the exhibits being manufactured by the Rheinisch-Westfalische Sprengstoff Actien Gesellschaft in Cologne and the Société Industrielle de Celluloid in Paris.

RUBBER

Finally, I will refer to one of the greatest successes and yet one of the most difficult problems of the chemical industry, viz., the production of synthetic rubber. I am proud of the fact that its production was successfully accomplished in the works which are under my management, and that I was able to follow every stage of this important discovery. Perhaps you would be interested to hear how the whole thing happened, especially as much that is untrue and misleading has appeared in the press during the last few weeks.

But first, a few words about the natural rubber. The Old World owes its knowledge of this substance to the New. This wonderful product became known in Europe shortly after Columbus discovered America. If I, coming from across the ocean, now bring you this colloid prepared there synthetically, I merely repay part of the debt which we owe America.

Hardly a generation ago, the southern part of this great American continent furnished the whole supply of the different kinds of rubber. Since then extensive plantations of rubber trees have been established in various tropical countries, and their yield has grown so enormously that the old home of wild rubber will soon be thrust into the background. This is a matter which involves many millions; consequently a very serious economical problem confronts South America.

You all know that caoutchouc is made from the milky sap of numerous species of trees and shrubs and the grotesquely formed lianas by various coagulation processes, and that this product, on being suitably treated with sulphur or sulphur compounds, *i. e.*, by vulcanization, acquires its valuable and characteristic properties. The synthetic method took quite a different route. By breaking up the very complex molecule which rubber doubtless possesses, by pyrogenetic processes, *i. e.*, by dry distillation, a veritable maze of all kinds of gases, oils, and resins was obtained, as well as a colorless fluid resembling benzine, to which the investigators gave the name of "isoprene." It was Bouchardat who first expressed the belief that this isoprene, which is obtained in very small quantities and in an impure form by the dry distillation of caoutchouc, might be closely and intimately related to caoutchouc itself. This important question was then eagerly discussed for several decades by the scientists of all countries, and opinions were sharply divided.

As far back as the eighties, Tilden claimed to have prepared artificial rubber from isoprene by treatment with hydrochloric acid and nitrous acid. But neither Tilden nor his assistants, though they worked strenuously for years, succeeded in repeating the experiments. Moreover, numerous other investigators, among

them our chemists, were unable to confirm the results. In 1894 Tilden found, however, that that isoprene which he had prepared about ten years before, on standing, had partially polymerized into rubber. In this way Tilden, in fact, was the first discoverer of synthetic rubber. But this method, which time has not yet permitted to repeat, is obviously not a commercial one. Dr. Fritz Hofmann of the Farbenfabriken vorm. Friedr. Bayer & Company is to be regarded as the real inventor of synthetic rubber, for, by the application of heat, he succeeded, as the first, in August, 1909, in polymerizing the isoprene molecules completely into the complex rubber molecule on a technical scale. Somewhat later Harries invented independently another method of arriving at the same result. Everyone is now in a position to repeat this exceedingly simple experiment himself, but in order to confirm Hofmann's results, it is necessary to employ pure isoprene.

The practical value of this rubber, of which many samples are among the exhibits, has been tested by the highest authorities in this branch of the industry, whilst Prof. Karl Harries, whose unremitting labors, extending over many years, prepared the soil for Hofmann's synthesis, has carefully examined the chemical constitution of the substance.

Isoprene belongs to the butadienes. It was therefore to be assumed at the start that betamethylbutadiene would not hold a peculiar and isolated position amongst the butadienes in general. It was argued that other members of this interesting group of hydrocarbons would yield analogous and homologous rubbers on being heated. In the synthesis of products occurring in nature, there is always a possibility of producing such variations, and our endeavors to find out whether this was true in the case of rubber were crowned with success, for today several representatives of the new class of caoutchoucs possessing different properties are known and are being submitted to technical tests. Exact proof of the existence of the class of isomeric and homologous caoutchoucs was also first presented by Eberfeld.

To you who hear this account and see these beautiful specimens, the matter appears very simple, intelligible, and clear. In reality, however, it was not so. The difficulties which have been overcome were great indeed and those which still remain to be surmounted, in order to produce a substance equal to Para caoutchouc in quality and capable of competing with cheap plantation rubber costing only two marks per kilo, are still greater. But such difficulties do not intimidate the chemist and manufacturer; on the contrary, they spur them on to further efforts. The stone is rolling, and we will see to it that it reaches its destination. The end in view is this, that artificial rubber may soon play as important a rôle in the markets of the world as does natural rubber. The consumption of rubber is simply enormous. Finished articles to the value of three milliard marks ($750,000,000) are manufactured every year, and the raw material from which they are made, calculated at the present market price of twelve marks ($3) per kilo, costs one milliard marks ($250,000,000). Other tasks which the chemist has on hand shrink into insignificance compared with this gigantic problem. The laurel wreath will not adorn the brow of the wild dreamer but that of the scientist who, cool and persevering, pursues his way. The seed he sows ripens slowly, and though, according to the statements in the press, all this is mere child's play and the problem has been solved, I leave it to your judgment whether this is true or not, like much that printer's ink patiently transfers to paper. I am right in the midst of this excitement. I have employed articles made of synthetic rubber and for some time I have used automobile tires made of this material. Yet, if you ask me to answer you honestly and truly when synthetic rubber will bring the millions which prophets see in its exploitation, I must reply that I do not know. Surely not in the immediate future, although synthetic rubber will certainly appear on the market in a very short time. I hope to live long enough to see art triumph also over nature.

We are now at the end of our journey. We have flown not only over the field

of Germany, but also over all other countries where the chemical industry is cultivated. We have taken a passing glance at the untiring striving for advance, the restless search for the hidden and unknown, the ceaseless efforts to acquire more technical knowledge, as witnessed in the great laboratories and factories of our mighty and ever-growing industry. We will now guide our airship into the haven whence we set out and land where our co-workers have gathered from all the countries of the earth to recount whatever progress each has achieved and to discuss, in public and private, the problems which have been solved and those which still await solution.

A REMARKABLE ORGAN

A remarkable development with organ pipes by an alumnus of the Massachusetts Institute of Technology has been the installation of an 128-foot stop in an organ in Lowell. This he calls the *Tonus Infra Totissima*, and its lowest pipe is CCCCCC, according to the symbols of musicians. It has been produced by William B. Goodwin, '79, a man of means, who, from pure love of the work, began the study of organ construction, which has now become his profession. The city of Lowell is remarkable in the number of fine organs that it possesses, and the quality of a number of these is due to the work and advice of this student of music.

It is not so long ago that the 32-foot pipe was the lowest tone to which makers could go. The great organ which a generation ago was the pride of old Music Hall in Boston, was notable in that it had a stop of these great pipes in its front. The lowest note (CCCC) vibrates at the rate of sixteen a second, and this being very nearly the point below which the vibrations cease to form continuous sound, it was believed that the practical limit had been reached for organ pipes.

Within the past twenty-five years much has been added to the knowledge of organ building and the electric action has been no small factor in the advance. It has relieved the key of the cumulative weight of stops as they are added, a failing of the old tracker organ action, and has permitted new combinations of strength and beauty, impossibilities in earlier days.

It was a daring explorer into the "tombs of sound" who a few years ago ventured on a stop of 64 feet, CCCCC, *Tonus Profundus*. This was done in Sydney, and a stop of full-sized reeds is there to be heard.

It is well known that quality of tone, the factor that makes the violin different from the flute, is dependent upon the selection and proportionate strength of the overtones. Those who have had the pleasure of listening to the recent lectures of Professor Dayton C. Miller of Cleveland have heard for themselves how a number of independent organ pipes (representing the overtones), when sounded together, produce thus synthetically the quality desired in the resultant tone. In the same way, the overtones that give the quality to the *Tonus Profundissimus* may be assembled in an organ and thus it is that the effect of it is produced without the necessity of using a pipe of that length. Synthetic 64-foot stops are now to be heard in a score of organs the world over.

The advance that Mr. Goodwin has made is even more remarkable, for in the 128-foot stop the lowest C vibrates only four times a second. It is this that he has introduced into the organ of the Immaculate Conception in Lowell, the *Tonus Infra Totissima*. The stop is described as "a mighty atmospheric throb of most awesome majesty, which, while soft, is so pervasive as to hold its own against the mightiest crashes of the full organ." It is true of course that these grave and "remote" tones have their place only in slow and solemn music, such as the recent reversion to the Gregorian encourages.

The Immaculate Conception organ has long been known as a fine organ. Some time ago the provision made by its builders for a 32-foot stop was fulfilled. Since that time a 64-foot stop has been added, and today it is unique in having the 128-foot, a pedal stop that is an octave lower than any other in the world. J. R., JR.

DURABILITY OF CONCRETE IN SEA WATER

SOME INTERESTING EXPERIMENTAL TESTS OF THE EFFECT OF FROST AND SEA WATER ON VARIOUS CONCRETE MIXTURES UNDER DIFFERENT CONDITIONS

It has long been considered that the combined action of frost and sea water in northern climates would be fatal to the long life of concrete structures. To disprove this theory, twenty-four 16 foot concrete piers or specimens were made in January, 1909, by the Aberthaw Construction Company, and have been subjected since that time to the rise and fall of the tide in the Boston Navy Yard.

They are so placed that the salt water rises nearly to the top of each specimen once in twelve hours, while six hours later it drops nearly to the bottom of the specimen. In cold weather the specimens are thus alternately frozen and thawed. Some of the specimens were mixed so lean in cement that they were necessarily somewhat porous, and it must be considered that any porous masonry subjected to this treatment would show spalling. Others, however, richer in composition, are still in almost identically the same condition as at first. It is evident, however, that only long years will show whether any of the specimens will prove permanent.

The first three specimens were made of one part cement, one of sand, and two of stone, and mixed dry, plastic, and very wet, respectively. The next three were made of approximately one part cement, two of sand, and four of stone, but so proportional after mechanical analysis of materials that the excess of cement over voids of sand should be 10 per cent. and the excess of mortar over voids of stone should be 10 per cent. These three were mixed dry, plastic, and very wet, respec-

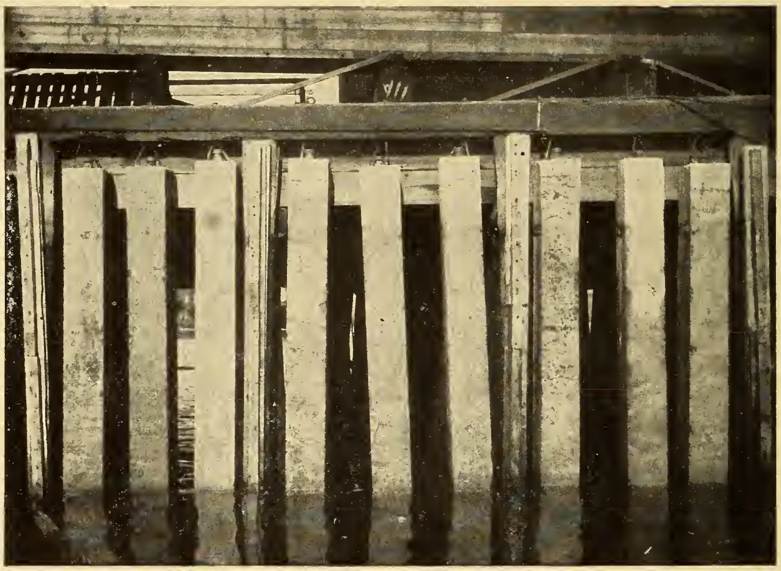


Fig. 1. This view shows nine of the piers at almost low tide. It gives an indication as to the original method of support

tively. The next three were made of one part cement, three of sand, six of stone, and mixed dry, plastic, and very wet, respectively.

Ten samples were made in pairs, one of each pair being mixed 1 : 1: 2 and the other 1 : 3 : 6. All of these were mixed wet. Two were made from a Portland cement practically free from iron; two of a commercial Portland cement high in alumina; two of a commercial cement low in alumina; two of an iron ore cement practically free from alumina; two of slag cement.

The other five samples consisted of one part cement, three of sand and six of stone, and were mixed wet. They were intended to show the effect of waterproofing on a porous concrete. Number 20 was most thoroughly well mixed—much better than commercial mixing. Number 21, which was mixed with salt water instead of fresh water, was lost in handling in 1912. Number 22 had one-tenth part by weight of hydrated lime substituted for an equivalent amount of the cement, thus making the mixture really 0.1 hydrated lime, 0.9 standard Portland cement, three parts sand, six, stone. Number 23 was mixed with a Sylvester solution of soap and alum; number 24 contained finely pulverized clay to the amount of 5 per cent. of the weight of the cement.

Between periodic inspections, the specimens are hung under the cap log of one of the wharves in the Navy Yard, as shown in figure 1. Each specimen measures about 16 inches square in section and weighs a little more than 4000 pounds. The weights per cubic foot in the different specimens vary from 142 to 152 pounds.

Illustrations are given of four typical samples photographed in December, 1913. The extent of action is indicated in each of the photographs.

Figure 2 represents specimen No. 1, which was rich in cement but cast very dry. The face, as shown in the photograph, was badly eroded for the full length, but the sides and back were probably as good as when the pier was poured.

Figure 3 represents specimen No. 3. This was the same mix as specimen No.1, but it was cast very wet, the concrete

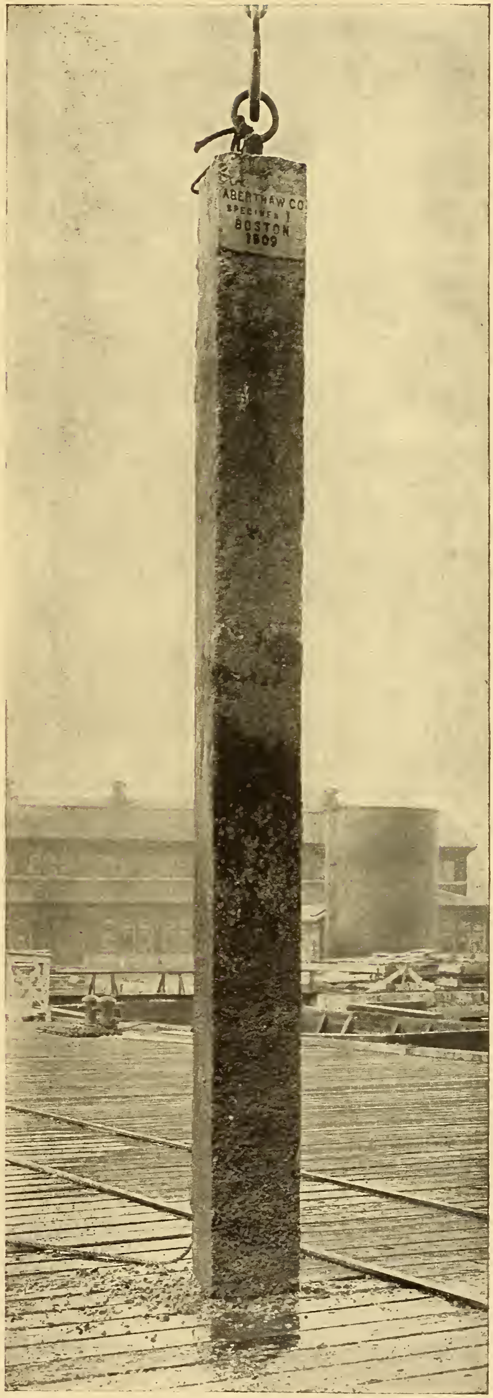


Fig. 2

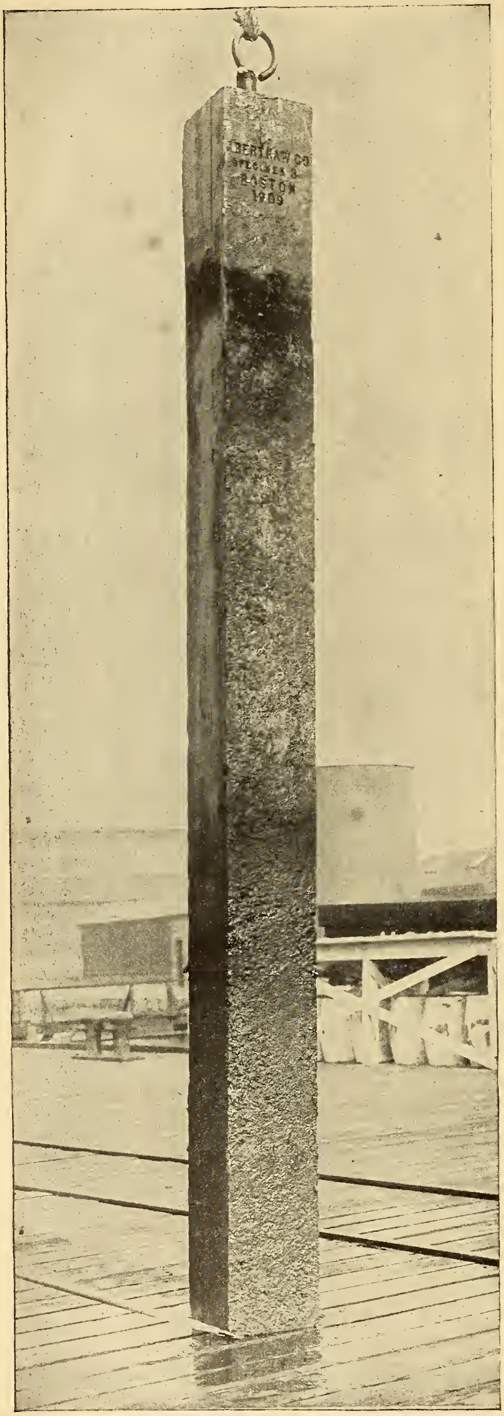


Fig. 3

Fig. 4

being soft enough to run out of an overturned barrel, but it would not flow like syrup. Although this shows a slight pitting action on both the face and the back, yet the greater part of this specimen is as good as it was originally.

Figure 4, specimen No. 19, shows the corners badly eaten away. This was very lean in cement, being mixed one to three of sand to six of stone. The cement used in this specimen was made from slag. The corners are all gone, several inches deep in some places, and the back is badly eaten, partly exposing the steel reinforcement in places. The concrete is soft and crumbly, although in the lower portion, where the specimen was continually immersed, even at low water, the condition is very fair.

Figure 5, specimen No. 18, also made of slag cement, but very rich in cement—1 : 1 : 2, has stood up splendidly under the test. It is good all over, the corners still being sharp, only a slight pitting action noticeable on the back.

Although no final conclusions can be drawn, it is interesting to note that those specimens which have shown the best results have been richest in cement and were mixed quite wet. Correspondingly, those specimens which have shown the poorest results have been lean in cement and mixed quite dry. All the specimens were cast horizontally, with reinforcing bars running the entire length near two opposite corners. They were allowed to season six or seven weeks before being hung in the water.

It should be noted that the cuts have been made from photographs which have not been retouched.

In a paper by Hess, of the Vienna Radium Institute, he tells of his investigations, by means of balloon ascents, of the penetration of radiation which occurs in the upper atmosphere. He states that at 2,000 meters the penetrating rays rapidly increase. He concludes that they cannot come from the earth, or the air which has its origin in the earth, but must be derived from some extra terrestrial source.

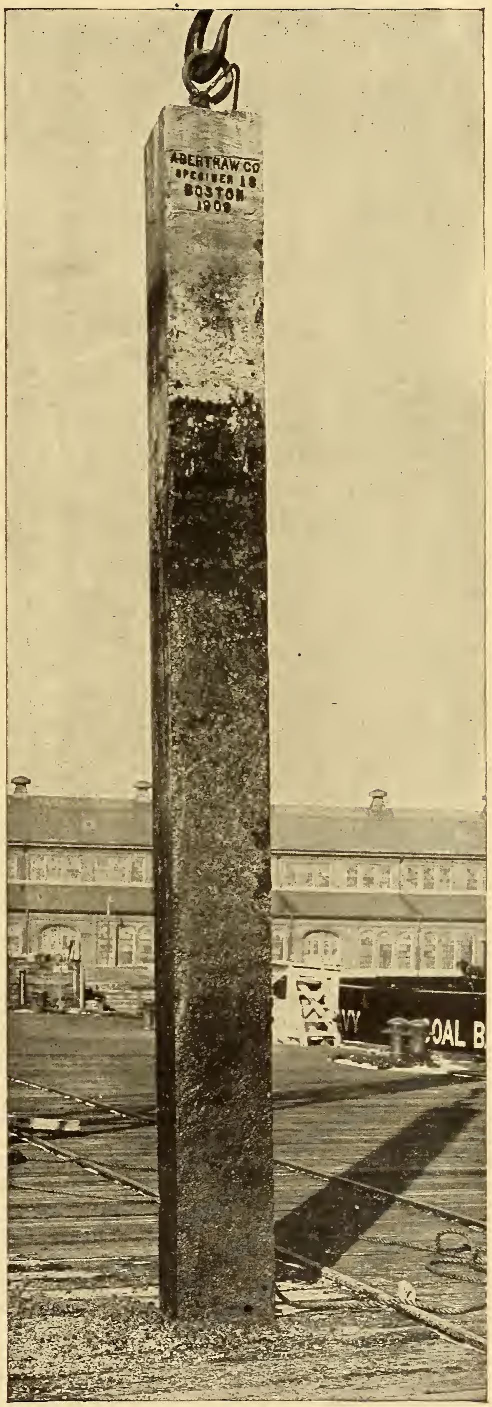


Fig. 5

WONDERFUL USES OF THE GYROSCOPE

The first article in the first number of Science Conspectus was on the subject of the gyroscope by Elmer A. Sperry. In that article Mr. Sperry referred to his gyroscopic compass, which he was then experimenting with, prophesying its wide use, when further perfected, especially in the Navy, and he also touched on the possibilities of the gyroscope as an aëroplane stabilizer. Since that time, Mr. Sperry has been assiduously working on both these problems. A few compasses were then in practical use and since that time they have been installed on many of the larger United States warships.

It is a well-known fact that the magnetic compass does not point to the true north, but varies with the seasons, and there is also a diurnal variation. In addition to that there are local disturbances which make it necessary to adjust compasses with great exactness, and also to provide for variations. Although the gyroscope has also its variations, the new Sperry apparatus is so devised that it holds exactly true to the geographical meridian, requiring no correction factors and no correction tables.

Announcement was recently made that Mr. Sperry and his son had startled French aviators by the remarkable stabilizing properties of their gyroscopic apparatus for aëroplanes. The idea of using the gyroscope for this purpose is very old, and has been experimented on by a number of people. Mr. Sperry's application of the gyroscopic principle, however, is an entirely new one. He does not attempt to actually stabilize aëroplanes by the gyroscopic principle. When a gust of wind strikes any part of the guiding planes, the gyroscopes move in opposition, and in so doing operate a delicately balanced valve in the air supply line, which, acting on a piston, pulls or pushes the required lever, thus operating the ailerons or wing tips of the plane at the end of the tail. If there were no tempering arrangement to perform these operations with something approximating intelligence, the movement of the aëroplane thus acted on quickly and positively might, at times, throw the operator out of his seat, when the wind pressure was excessive.

Mr. Sperry has cleverly introduced here an anemometer; that is, a wind-measuring device. When the wind pressure is great, the anemometer operates to raise the fulcrums of the levers, so that the movements of the wind tips or tail planes are reduced in scope. The spinning gyroscopes are operated by a little dynamo driven by a belt from the crankshaft of the engine.

The exhibition of the Sperry automatic stabilizer in France won the French War Department prize of $10,000, offered for apparatus for increasing the safety of flying machines. The following is an interview with Rene Quinton, president of the National Aëroplane League of France, who went up with Mr. Sperry.

"Mr. Sperry and I started about noon in very unfavorable weather. The wind was so strong that the water of the Seine was very rough. Just after starting, the pilot began to ascend, and in a few minutes he let go the wheel. As we passed in front of the stand where the members of the committee were, he lifted both hands in the air. I, of course, being close to him, was already assured that he was touching nothing with his hands.

"The aëroplane still continued to go up. We were hundreds of feet above the trees. I could see the branches waving wildly in the wind, the heavy boughs being bent by the force of the gale, but it had not the slightest effect on the automatically controlled machine. I felt as if we were in an ordinary machine in perfectly calm weather.

"When we reached a height of about 800 feet we volplaned without the aid of the hand control. It is known that when aviators want to volplane they have to shoot the machine almost straight

down for a while in order to get the necessary speed when the motor is shut off. Could the Sperry machine do this without the aid of human guidance? Mr. Sperry proved that it could. He told me what he was going to do, stopped the motor and lifted his hands in the air. For five or six seconds nothing happened. The aëroplane seemed to be motionless. Then, suddenly the speed diminished and the machine dived like a dolphin.

"Then Mr. Sperry showed me another trick of his machine. We flew for nearly half a mile with the machine inclined at an angle of forty-five degrees. Sperry never touched the machine with his hands. The machine guided itself and it is worthy of remark that in this abnormal position, furious gusts of wind had not the slightest effect on its position. It defended itself automatically against the breeze."

After Quinton had made his flight, Sperry went up with a United States naval lieutenant, retired, who, as representative of several United States naval attachés to foreign embassies, flew the machine with the aid of gyroscopes. He never before had tried to pilot a machine, but as all he had to do was work the rudder, he made with ease a flight which, if performed a few years ago by a man who had given his life to aviation, would have won worldwide applause. It was blowing as hard during this flight as during the others.

One of the great advantages of the stabilizer is shown when banking on a turn. In machines manipulated by the ordinary hand controls, it is necessary when turning to use three controls which govern the rudder, the lateral dip of the machine and the fore and aft rise or fall. It is the complexity of this movement which makes it dangerous in the hands of a novice. But with the stabilizer it is only necessary to turn the rudder; the gyroscopes do the rest.

Once, young Sperry and his mechanic, Emile Cachin, climbed up into the air above the Seine, and the mechanic walked out upon a wing as calmly as if strolling upon the earth. The stabilizer kept the flying boat in a horizontal position. The mechanic tried to disturb the equilibrium of the machine, but the gyroscope would not permit it.

CRACKING OF BRONZE RODS

It often happens that some alloys of copper, which have been worked cold, unaccountably crack, sometimes merely on the surface and sometimes entirely through the cross-section of the piece.

In the building of the Catskill aqueduct several kinds of bronzes were used, principally manganese, Tobin and naval bronzes, the quantity of manganese bronze being largely in excess of the others. In this work an immense number of seats, valves, bolts, anchor rods, etc., were used, and it was discovered that hundreds of them, when assembled, were found to be circumferentially cracked. This caused a great deal of alarm and the subject was given a close study by the engineers in charge. It was found that those specimens that had been incidentally or deliberately annealed in the course of manufacture semed to have escaped from this trouble. It was also found not to be peculiar to any one kind of bronze but apparently affected those pieces that had been worked cold and had not been annealed. It was found that the cracked bronze was much harder than the material that did not crack. The theory was evolved that this season cracking was due to the initial stress of the metal augmented by the stress introduced by changes in temperature. These investigations have led to a series of standard specifications for such metals, which will, no doubt, avoid the serious menace of failure of pieces doing important duty.

EYE-PRESERVING SPECTACLES

In a paper recently read before the Royal Society of London, Sir William Crookes described a method of making glass for spectacles which will cut out the injurious ultra-violent rays of the sun in tropical countries. By another formula, glass spectacles are made to protect the eyes of glass-blowers by cutting off 98 per cent. of the heat rays.

COMMERCIALIZING OZONE

Ozone of any quality or quantity is now procurable. It is not possible to store this gas, but it can be manufactured by the use of any one of several types of ozonizers suited to the different purposes to which ozone is put. Two properties govern its use; its instability, and its insolubility in water in the ordinary sense of the word. The latter necessitates long and very intimate mechanical contact, which means special apparatus.

Ozone is a strong oxidizing agent, and if brought into close contact for a sufficient length of time causes complete sterilization. It is an excellent agent for purifying water. The amount necessary for ordinary water is very small. The length of time required naturally depends upon the degree of impurity. Wine has been ozonized in an attempt to age it artificially, but with poor results. Milk, likewise, cannot be successfully ozonized, although the futile efforts to treat milk on the part of Tindal and Schneller of Holland led to the discovery of this method of purification and sterilization of water.

Ozone actually burns up most of the organic matter in water. The latter after treatment is not only perfect from a bacteriological standpoint, but has no unusual taste, no odor, and no discoloration. The first bacteria to yield to ozone are the most dangerous pathogenic ones, including the typhoid bacillus and the cholera vibrio.

Ozone has been used in some schools and public buildings to purify the air. Its value for this purpose is much disputed. It is a question whether it does more than mask the unpleasant odors due to respiration, perspiration, and so on. Those who favor the use of ozonizers for purposes of air purification declare that it is these odors which prevent people in a close room from breathing deeply enough and that the destruction of the odors, harmless though they may be in themselves, is of value for that reason. In any case, the concentration of ozone, where used for this purpose, must be exceedingly low, since its powerful oxidizing action would be liable to injure the delicate character of human mucous membranes. The value of this gas as a therapeutic agent in cases of phthisis in early stages, anemia and obesity is also much disputed. Some claim that ozone will never become of therapeutic value, owing to the belief they hold that all of it is destroyed before it reaches the lungs; others maintain from their own observation that there actually is an increase in the oxyhæmoglobin percentage, which would not be the case if all the ozone had been absorbed by the mucous membranes.

Considered as an asset to the industrial arts, the cost of production in most cases has seemed so far to seriously limit its value. But this is an extensive field for investigation. As a bleaching agent it is obliged to compete with chlorine which is both cheap and efficient. It seems possible that some means may be found to increase the present yield of ozone to far more than ten grams per kilowatt hour, the highest yield at present. Ozone distinctly surpasses chlorine, however, when it is a question of the quality of the product. Paper pulp treated with a weak application showed a length of fiber several times that produced by chlorine bleaching. To the trade this is a very important feature, inasmuch as upon the length of fiber depends the amount of filling it is possible to add to the pulp in order to obtain a given weight of paper. Cotton and beeswax have been bleached by ozone. The latter requires a great deal of ozone due to the large amount of organic matter that must be destroyed. Sugar cannot successfully be bleached by this agent since the process interferes somewhat with crystallization. Glue loses its sticking properties. Yet flax has been well treated with ozone, for flax contains glue, the adhesive properties of which were destroyed by the treatment. Flour subjected to ozone retains a dis-

agreeable taste. The oil industries require a large amount of ozone, a fact which renders the expense an objection; but the prospects are that the elimination, by its use, of taste and smell will go far to counterbalance this drawback. Ozone also promises good results in the production of varnish from linseed oil in the improved transparency of the article. This is due in all probability to the fact that the oil has not been subjected to a high temperature. This process, moreover, dries oil for linoleums with considerable saving of time.

The theoretical yield of ozone is a thousand grams per kilowatt hour. In the highly probable event of a large increase in the present yield, it is easy to see from what has already been shown by experiment that ozone might revolutionize certain industries. E. T. S.

STATUS OF THE ELECTRIC FURNACE

In a recent bulletin of the Bureau of Mines, Mr. Dorsey A. Lyon of the department discusses the electric furnace for making iron as compared with the blast furnace. He states that the former is not yet developed as a competitor of the blast furnace. The feasibility of smelting iron ores in an electric furnace depends on the relative cost of blast furnace fuel and of electric power. Only hydro-electric power is used for operating electric iron furnaces at the present time. In general, there are few localities where the electric smelting of iron ores would be feasible with the electrical energy costing annually more than twenty to thirty dollars per kilowatt-hour.

The aspects of electric furnace steel plants are presented by Mr. Robert M. Keeney of the Bureau, who states that the cost of power does not enter so largely into the final result as it does in some other electro-metallurgical processes. Plants can be operated successfully under a power cost of one cent per kilowatt-hour in localities where the material can be obtained at the price common to other processes. Mr. Keeney states that since the advent of the electrical furnace it has been slowly adopted for refining steel. For the complete refining for the highest grade of steel, the electric furnace is now thoroughly established in Europe. Any product that can be made by the crucible process can be made with the electric furnace, and in most cases with cheaper raw materials and at a lower cost; also by the use of the electric furnace it is possible to make complex alloy steels with precision. The report seems to show that with a larger use of the high grade refined steels, the electric furnace will have greater vogue.

There is a demand throughout the country for a high grade of rail and structural steel at an increased price over acid Bessemer or even the basic open-hearth product. Electric furnaces cannot, however, compete with the old processes for making present grades of steel. It is in combination with either the Bessemer or open-hearth process that it seems destined to be prominent in the future.

A WIRELESS DANGER ABOARD SHIP

A circular recently sent out by the United States Bureau of Navigation calls attention to the danger of improperly insulated wireless apparatus on shipboard.

The operation of the radio-apparatus generates in the antennae enormous potentials or very high voltages. Any defect in the insulation causes electric sparks to pass over the insulator in an effort to reach a ground. Many tank vessels, and some of the cargo vessels, carrying gasolene and similar explosives are equipped with wireless apparatus, and in some cases vent pipes are led up the mast and have openings in the vicinity of the antennae. Under certain conditions an explosion might result.

It has been determined, from careful measurements, that the sootfall of Pittsburgh is from 595 to 1,950 tons per square mile per year. Statistics of Great Britain show that in the industrial section of Leeds the annual fall is 529 tons; center of London, 426 tons; Glasgow, 820 tons.

RESTORATION OF EXTINCT REPTILES

What did animals, long extinct, look like when alive, is a frequent query to the paleontologist. The proportions of the body can be more or less easily restored. A recognition of the fact that the prominence of projections and rough places upon the bones of the body indicates the size of the muscles attached thereto, enables the student to make the proportions of his model or sketch with considerable precision. But what did the surface of the body look like? Did it have a smooth skin or was this covered with scales, horn, feathers or hair? This query is especially pertinent if the numbers and arrangement of the bones prove the animal to belong to the great reptile family, since among living reptiles variety in this respect is manifold.

Fig. 1. Impression made by the skin of the side of the body of an ancient reptile in the mud forming its final bed. This dinosaur, Stephanosaurus marginatus, lived some five million years ago, during Cretaceous time, in Alberta. From Lambe

A recent paper by Lambe,* the vertebrate paleontologist to the Canadian Geological Survey, shows one of the aids which the rocks bring to the solution of this query. In the ancient rocks of Cretaceous age in Alberta were found not only the bones of a reptilian dinosaur but, upon the surrounding rock, the impress of its skin. When buried in the ancient delta, the soft mud easily received this impress and before the disintegration of the flesh and its covering of skin, the mud had become sufficiently hardened to preserve the dinosaur coat in relief. Similar finds have within recent years revealed the superficial appearance of various extinct reptiles. Only a beginning has, however, been made in this direction. H. W. S.

NEW USE FOR THE BLOWPIPE

The superstructure of the old Jackson Street Bridge over the Chicago River in Chicago was removed in twelve days by cutting apart with blowpipes and swinging the parts onto barges by derrick boats having sixty-foot steel booms. The bridge had a three-stress span, two hundred eighty feet long and fifty-eight feet wide. A new bridge was necessary to give greater width of travel. It required very nice calculation to plan the order of the removal of the different sections of the bridge so that no accidents would happen.

HARDENING SOFT FATS

By introducing hydrogen into soft fats in the presence of nickel or palladium, either in a pulverized form or in aqueous suspension, the oils or fats are hardened and the melting point is raised; thus an oil of the consistency of ordinary cottonseed oil can be converted into a firm, semi-solid fat with many of the properties of lard. This process destroys all coloring matter and odor.

* Lambe, Lawrence M. *The Ottawa Naturalist*, vol. 27, p. 133, 1914.

Fig. 2. Restoration of a reptile closely related to the preceding. The surface markings of this dinosaur, Trachodon annectens, are almost entirely known, the parts unknown are left blank. The most complete mold of the epidermal markings of this animal found are from the Cretaceous of Wyoming. From Osborn

BOTTLE-NECK CAVES OF KARST

Near Trieste the Guilian Alpine Club has been investigating some very curious caves, which unlike the ordinary ones have vertical sides or even flask-shaped profiles. One at Basiviz is four hundred feet deep and eighty in diameter, and one at Fernetich does not reach the surface, being entered through a "window" in another well. At Opicina there is an underground group of tubes entered through a single mouth. A few have water and are used for wells.

THE TRIPOD OF EVOLUTION

A bird's-eye view of the plant and animal life which has existed upon this earth from early geologic time to the present, forces clearly to mind the fact that throughout this long procession of organic forms the lowly form has been succeeded by the more highly developed. Nature's coherent plan of action has been the evolution of such adaptive structures that the amount of time needed for the primitive and fundamental concerns of life—self-protection, sustenance and reproduction, has become less and less for each succeeding generation, thus more and more freeing the individual for higher uses of instinct and intelligence. Though the why and how of this evolution is still far from being answered, yet its results are visible in the lines of descent in the plant and animal kingdoms.

The different methods pursued in tracing these lines of descent may be grouped under three heads—comparative anatomy, embryology and paleontology. Of these the first is the oldest and forms the foundation of the other two; it confines its inquiries to a comparison of the forms of living organisms. The second is similarly concerned with the living; it is the study of the development of the individual from the egg or seed to the adult. The study of the developmental stages of any animal or plant reveals much of its ancestral history, since it has been found that, in general, any individual passes, in the course of its development from the egg to maturity, through stages which resemble the adult stages of its successive ancestors in geologic time, that is, the individual history repeats the ancestral. As a division of embryology may also be included the comparatively new science of genetics. Paleontology, deriving its evidence from the remains of organisms no longer living, must make use of the methods of both comparative anatomy and embryology; it must compare the fossil forms both with the living and with each other, and must, whenever possible, study the young of each species. Conspicuous success has, for example, attended the study of the young of the ancient extinct crustaceans—the trilobites and eurypterids.

It is upon this tripod of evidence that is built our modern conception of evolution. To illustrate the method: Comparative anatomy shows that all domestic horses as well as the wild horse, zebra, wild ass and quagga are, except for a few surface characters, such as coloration, tail, mane and size of ears, similar, structure for structure. Embryology shows, amongst other features, that the horse passes through stages in which it possesses more than one toe on each foot, hinting thus at successive ancestors which, as adults, were characterized by five, four and three toes. Paleontology finds fossil remains of those early stages, extending backwards from the present, first into forms but slightly different from the living horses and found in the superficial rocks, through forms with three toes on each foot and short teeth in intermediate rocks, to the small four- to five-toed ancestral horse in the lower rocks. None of these ancestral types have continued to exist to the present.

In the case of the scallop (Pecten), however, one of the earliest ancestral forms has persisted to the present. Comparative anatomy shows that this Pecten is closely related to the living Spondylus. In its embryology, to consider the shell alone, it passes through stages in which (1) there are no ribs; an earlier one (2) in which there are no ears; and a still earlier one (3), with the shell triangular and bearing a row of pits along the hinge margin. Paleontology finds the adult ancestral shells down in the strata of the Paleozoic era corresponding to the embryonic stages of the living scallop, and in succession in the rocks from below upwards corresponding to their appearance in the individual. (It is the form with the character of (3) above, which has persisted

to the present.) It likewise corroborates comparative anatomy in its conclusions by finding connecting links between the living genera.

Thus it is seen that by means of these three kinds of data a fairly complete idea may be gained of the ancestral tree of any individual. Each line of evidenec by itself, is incomplete. The reading of the evolutionary record has been compared to the reading of a book. In comparative anatomy the leaves present the true facts but are arranged in no order, so that one does not know which to read first. In embryology, the leaves, while usually arranged in the proper order, lay too much emphasis on some facts and entirely omit others which are equally important in the ancestral history. In paleontology, however, the pages are in perfect order and present true facts because the actual remains of the ancestors are preserved just as they occurred in succeeding geologic periods. Since, however, only a few cf the total number of individuals that flourished in the past have been preserved as fossils, it must be acknowledged that comparatively few pages of the vast total that make up the complete paleontologic record of past life have been preserved for our reading.

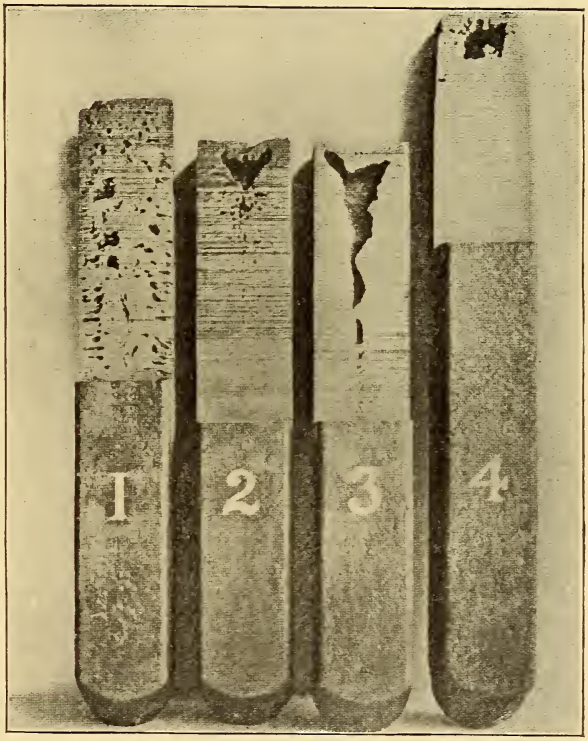
H. W. S.

SOUND STEEL INGOTS

Sir Robert Hadfield, the celebrated English steel manufacturer, has given a great deal of study to the production of perfectly sound steel ingots, and his results have attracted world-wide attention among steel manufacturers and large consumers.

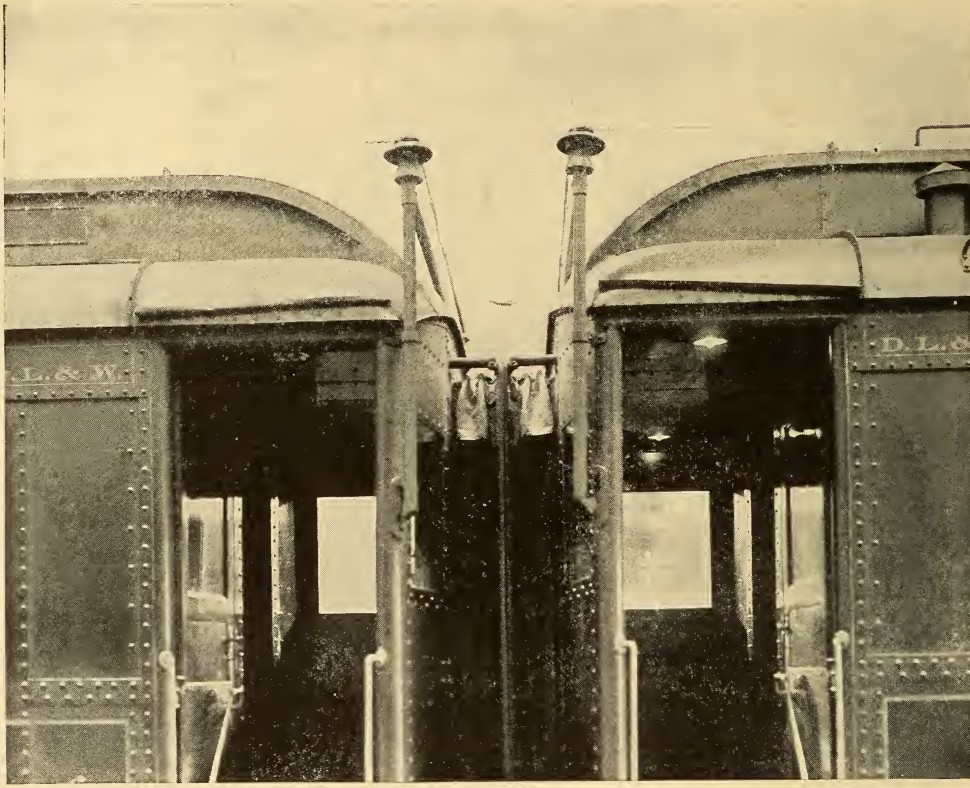
In the illustrations, which we publish by the courtesy of the *Scientific American*, are pictures of four ingots which have been cut through the middle, to show the comparative amount of piping in the specimens. In the case of ingot No. 1, the steel was poured into the mold just as it came from the furnace. Ingot No. 2 shows the same steel as the first, except that it was "quieted" with the addition of .036 per cent. of aluminum. The amount of aluminum was increased to .09 per cent. in the third, and although it is entirely without blow-holes, it is piped deeply at the top, making large waste necessary.

The experimenter next directed his attention to a mold for keeping the upper part of the ingot in a fluid condition



1. Ordinary steel as it comes from the furnace. 2. The same steel with .036 per cent. of aluminum added. 3. Same as No. 1, with .09 per cent. of aluminum. 4. Effected by keeping top of No. 3 very hot while bottom was cooling

while the lower part is solidifying. He accomplished this by placing over the top of the molten metal a thin layer of slag with a bed of burning charcoal above it. The result of this method is shown in ingot No. 4. This, it will be seen, is free from blow-holes, and also from the deep piping which appears in No. 3. The charcoal was kept in a state of violent incandescence by a blast of compressed air.



The aerial consists of a quadrangular closed loop on each car, supported at each corner by insulators on iron pipe attached to the corners of the car. They are raised eighteen inches above the roof of the car

WIRELESS ON RAILROADS

The equipping of a train on the Lackawanna Railroad with wireless telegraph apparatus has excited much general interest. Just what its economic value is cannot be determined on short time trial, nor with a single installation. It has, however, proved of the greatest use in a number of ways. On one occasion the conductor of a train became ill thirty miles east of Scranton, and instead of stopping the train to send a telegram asking for a relief conductor, the wireless operator communicated with the Scranton station and the relief conductor was waiting on the arrival of the train. On other occasions in leaving Hoboken it was discovered that another coach would be needed at Scranton. The car was ordered by wireless and was all ready to be attached to the train upon the arrival at that station. Law breakers have been discovered, and officers were summoned to meet the train at the next stopping place. In addition, of course, commercial telegrams are being sent from this train, and regular toll-rates are being prepared.

Speculation as to the possible usefulness of such installations on railroad trains covers a very broad field. These pertain largely to the running of trains by wireless instead of using the telegraph or telephone. It is obvious that communication can be had with any train anywhere on the road. There are, however, practical objections, which wider experimenting may overcome. The one great problem is that of the aërials; on account of the tunnels and low bridges

over the tracks it is impossible to have high aërials on the train. Now high aërials are necessary if messages are to be sent to great distances; so they were built extremely high at the stations to work with the low aërials on the trains. This makes the transmission of messages between the train and the stations more difficult than sending in the other direction.

We show herewith a cut of the train aërial as it is arranged on the cars, through the courtesy of *The Wireless Age*.

SOME STRANGE FISH OF OCEAN DEPTHS

The Prince of Monaco, who is primarily an investigating naturalist, has discovered fish with perfectly developed and evidently useful eyes living at a depth of three miles. Light never reaches those depths, for a photographic plate is not affected at one-fifth of that distance below the surface. The explanation seems to be that the fish, whose natural habitat is at the bottom of the ocean, come up at times to some point near the surface where their eyes are useful. In doing so they are obliged to adjust themselves to the difference of pressure, which, at the bottom, approaches twelve hundred pounds to the square inch, and near the surface forty-five pounds to the square inch.

Another extraordinary discovery is that the deep sea fish come near the surface at night, making a vertical migration of ten to twelve thousand feet back and forth presumably every day. A net sunk to the depth of twelve hundred feet will never catch these bottom fish in the daytime, but they can be caught at night with the same net at the same depth. The Prince's conjectural explanation is that the fish have organs for producing the light of phosphorescence, the purpose of which is supposed to be to attract prey. These fish come from the bottom to the surface to seek their food. They rise only at night because the light which lures their prey becomes visible and attractive only in semi-darkness. The suggested explanations of these phenomena are interesting, but may be far from the real truth.

Many queries arise in this connection, as for instance: How can the fish, at that depth, know whether it is day or night? and how can they preserve the use of eyes which practically never see the light of day?

FOOTINGS FOR CONCRETE PILES

A number of methods have been tried for the purpose of giving the best footing for concrete piles. By one method a tube is driven into the earth, the dirt in the pipe removed, and a moderate amount of cement poured in. By the use of a pile driver, with the weight dropping through the tube, the cement is forcibly spread out at the bottom while in a liquid condition, thus giving a mushroom-like footing, and at the same time making the ground firm. The concrete is then poured into the tube, which is gradually withdrawn as it is filled with the material.

Another method is to drive a steel tube into the earth, remove the earth-core, lower to the bottom a charge of dynamite, with electric connection from above; then fill the tube with concrete. The tube is drawn up a little way, then the charge of dynamite exploded. As the tube is withdrawn the concrete fills up the mushroom-like space at the bottom. The theory is that the pressure of gas liberated by the explosion makes a chamber in the earth as a footing for the pile and packs the earth at the same time. It is contended by some engineers, however, that the use of dynamite shatters the ground and is especially dangerous when in the vicinity of earth cavities and excavations.

A very simple and effective method is sometimes used in Germany which consists of dropping a weight, shaped like a plumb bob, by means of a pile driver. The constant dropping of this weight forces a hole into the ground, the earth about it being packed very hard. The concrete is then simply poured into the hole.

IMPORTANT X-RAY DISCOVERIES

Mr Herbert T. Wade, in the *Scientific American*, gives a description of Dr. Coolidge's recent discoveries in X-ray research. He says that in using the Roentgen ray tubes the penetration of the rays has hitherto been controlled by regulating the vacuum of the tube, and, except for minor details of construction and methods for such regulation of vacuum, there has been little fundamental difference in the tubes used. A new tube, however, designed by Dr. W. D. Coolidge, at the great research laboratories in Schenectady, has recently been developed in which an entirely new principle is involved. This tube gives a pure electron discharge and serves to reduce, in great measure, the actual time of exposure; in fact, it has been considered the most important contribution to Roentgenology since the birth of that science, and it has found an important place in various fields.

Through the courtesy of Dr. Lewis Gregory Cole, professor of Roentgenology at Cornell University Medical College, we were able to examine one of the new tubes which has been used with notable success. Not only is the operator able to adjust it with greater accuracy, but he is assured of stability and exact duplication of results, greater flexibility, a greater output of rays, a longer life of the tube, and the absence of indirect rays developed at various parts of the glass bulb which, of course, affect the sharpness of the impression. The new tubes have a vacuum about 1,000 times as great as the vacuum of the ordinary Roentgen ray tube and make use of a tungsten filament as a cathode, the material out of which, as every one knows, the filament in the ordinary tungsten incandescent lamp is made. This cathode, unlike that in the older type of tube, must be heated in order to render the tube active and capable of being excited. When a current from a storage battery raises the tungsten filament to the required temperature, the electrons are liberated from the cathode by the high potential current ordinarily employed and furnished from an induction coil or transformer.

The penetration of the rays from the tube depends upon the rapidity with which the electrons are thus shot out from the cathode, and this speed is controlled by regulating a low potential current from a storage battery in circuit with the tube, which acts to generate heat in the cathode filament. With one of the new tubes using a filament of twenty-five milliamperes, the stability of the tube will remain permanent for fifty minutes without perceptibly changing the penetration. This gives a Roentgenogram with a uniformity of excellence which has never before been obtained; and after the tube is adjusted to the desired degree of penetration for any given part of the body it may be excited with any desired milliamperage from 1 to 200, for the time required for a correct exposure. Uniform results can be obtained by decreasing the current and increasing the exposure or *vice versa*.

The controlling apparatus is such that an exact duplication can be obtained and, at the same time, the tube is so flexible that it can be operated at a penetration so slight as to show the fine blood vessels of the hand or foot at one instant, while at the next it can be increased so that a penetration far exceeding anything possible with the ordinary tube can be secured, thus making it available for all kinds of Roentgenographic and therapeutic work.

The life of the new tubes is placed by Dr. Coolidge at a minimum of a thousand hours of constant running, so that the tube is more likely to be impaired as the result of accident than from wearing out. The new tube avoids the detrimental effect of the indirect rays generated in the wall of the anterior hemisphere of the tube by secondary or deflected cathode streams which blur the image and give rise to secondary rays in the tissues of the body interposed. To one seeing the

apparatus for the first time the utter absence of fluorescence in the glass is most marked.

With the new tube a scale of length of exposure and current required with different lengths of spark gap has been compiled, which shows exactly what is needed in photographing the various parts of the body. In one instance ten exposures were made in four tenths of a second of actual time. With the stomach, using a spark gap of five inches and a current of 110 milliamperes, the time of 0.06 second was required, while for the detail of the spine, using a current of 30 milliamperes, 15 seconds would be required.

The original tests made in the research laboratory with experimental apparatus on animal tissue and strips of metal were repeated in Dr. Cole's laboratory and a series of test plates were made which showed clearly the differences obtained by varying the conditions in a number of exposures on the same subject.

BACTERIA AT FREEZING TEMPERATURE

S. C. Keith, Jr., of the Massachusetts Institute of Technology, has been making a study of the factors influencing the survival of bacteria at temperatures in the vicinity of the freezing of water. In making his conclusions from the experiments he says that low temperatures alone do not destroy bacteria. On the contrary, they appear to favor bacterial longevity, doubtless by diminishing destructive metabolism. Frozen food materials, such as ice cream, milk and egg substance, favor the existence of bacteria at low temperatures, not because they are foods, but apparently because they furnish physical conditions somehow protective of the bacteria.

It seems likely that water-bearing food materials as well as sugar solutions, glycerin solutions, etc., freeze in such a way that most of the bacteria present are extruded from the water crystals with other non-aqueous matters (including air) and lie in or among these matters without being crushed or otherwise injured; while in more purely watery suspensions, and, above all, in water itself in which the whole mass becomes solidly crystalline, they have no similar refuge but are perhaps caught and ultimately mechanically destroyed between the growing crystals. This theory would explain the absence of live bacteria in clear ice, their comparative abundance in "snow" ice and "bubbly" ice, and also the fact that the more watery food materials, when frozen, contain the fewest, and the least watery, the most living bacteria.

The comparatively rapid death of bacteria in non-nutrient materials at higher temperatures and their slower dying at lower temperatures agrees well with the theory of simple starvation or destructive metabolism. At the higher temperatures they perish quickly because they burn themselves out quickly; at the lower, more slowly, because they consume themselves more slowly. At temperatures where metabolism ceases altogether, they continue to exist in a state of suspended vitality similar to that exhibited by many other and higher plants which in the far north are subjected without apparent injury for long periods to temperatures much below the freezing point of water.

A BIOLOGICAL FORECAST

In a recent article Professor G. H. Parker of Harvard says:—

"If the green plant in sunlight can elaborate from water and carbon dioxide one of our chief food substances, starch, there is no reason why the biological chemist should not discover the secret of this process and imitate it on a commercial scale. Starch, I believe, has never been synthesized, but some sugars have been so constructed. Two years ago Stoklasa and Sdobnicky made the remarkable discovery that by the action of ultraviolet light on nascent hydrogen and carbon dioxide sugar was formed. Such discoveries as this suggest the means by which we are to throw off our slavery to the green plant and I am convinced that in time this overthrow will become so complete that our staple foods will be the products of the biological chemist."

CORROSION OF WROUGHT-IRON

The resistance of wrought-iron to corrosion is remarkable in spite of any statements to the contrary based on short periods of comparative tests. At Delhi, in India, there is a monumental column of this material which is over one thousand years old. It is stated on good authority that in various humid parts of India native-made iron, whose origin is too far back to be definitely known, is still seen fully exposed to weather conditions. At the Epping church, near London, there are some exposed iron handrails, one hundred and fifty years old, the section of which has not been diminished below the margin of safety during this period. This iron was probably smelted and puddled in small quantities, using charcoal for fuel, from particularly high-grade and easily reduced ore.

PLATINUM DEPOSITS

The American Consul at Wenden, Westphalia, has made a report of the discovery of platinum at that point in Germany, which yields from 0.9 to 1.9 troy ounces of platinum per cubic yard. This is said to be a higher content than in the Russian deposits. The extent of the deposit is not actually known, but it would appear that the platinum market would be considerably affected by the discovery. Ninety-five per cent. of the present annual production of 13,250 pounds comes from Russia. The demand exceeds the supply, and in twenty-two years the price has advanced from $89 to $488 per troy pound. Nearly one-third of the output is used in electro-technical industries, and another third in dentistry.

A NEW FISH-CURING METHOD

Vice-Consul General Eugene M. Lamb reports a new method recently introduced into the fisheries of Nova Scotia for preserving fish for shipment.

The fish are dumped into a tank of sea water filtered through willow charcoal to remove noxious gases and foreign substances. Brown sugar is placed in the tank to serve as a germicide for any organisms that may be active at low temperatures. The temperature of the water is then lowered to ten degrees centigrade below zero and 16.1 per cent. salt is added to prevent ice formation. After two hours of this treatment, the fish are ready for shipment to market.

The marine disasters of 1913 cost Great Britain $35,000,000. The losses on the Great Lakes in the United States are estimated at $4,700,000. The above figures represent only total losses.

SCIENCE CONSPECTUS

VOL. IV 1914 NO. 5

THE MYSTERY OF MATTER

WHAT IS KNOWN AND WHAT SCIENTISTS CONJECTURE ABOUT THE COMPOSITION OF MATTER, ITS PROPERTIES AND ITS PHYSICAL STRUCTURE

THERE has recently been published by the D. Van Nostrand Company an unusually entertaining treatise on chemistry by Geoffrey Martin, an English scientist. His object was to describe in an attractive way the triumphs and wonders of modern chemistry, and he has succeeded so well that the reading of the book has a peculiar fascination. Our readers will get an idea of the general character of the book from the chapter on "Matter" which follows:

The endless circulation of matter in the universe is, perhaps, one of the most wonderful facts with which chemistry has to deal. It is this endless change which causes the history of the most common and insignificant objects about us to be more astonishing than any fairy tale. What a wonderful story, for example, could be written of the material which forms our bodies! It came into existence in the immense depths of space millions upon millions of years ago, and wandered for ages through darkness and void until it reached our earth. Perhaps it fell upon the earth in a fiery meteorite, or perhaps it merely joined the huge fire mist from which our solid world condensed. Since then it has run round age after age in an endless circle of change. First it formed part of that vast primeval atmosphere which surrounded the globe, and blew in mighty winds around our planet; then it was absorbed into the body of some humble living being, and when this being died and its body decayed, the matter passed into the rich mother earth. Thence it passed into some plant by means of its roots; and from the plant it passed, by the process of being devoured, into the body of some animal; and from the animal again it passed to earth and thence to plants and animals again; and so on through an endless cycle of change, coursing through the bodies of innumerable multitudes of living forms, which stretch far back in a dim unending vista into the depths of time. Finally it reached man; yes, the very atoms which thrill and flash in our brains and muscles once formed part of a living plant or animal millions of years ago, and will again form part of a living plant or animal millions of years hence. In some form or other the matter which now forms our bodies will exist long after the whole present order of creation has passed away; indeed, it may well yet blow in the winds of worlds as yet unborn, and thrill in forms of life not yet evolved.

This ceaseless round of matter seems to have impressed Shakespeare, who has caused Hamlet, not pleasantly, to refer to the subject more than once. In Act IV, Scene 3, we have the man eating the fish

that has fed on a worm, which in its turn was sustained upon a dead emperor, and are shown "how a king may go a progress through the guts of a beggar." In Act V, Scene 1, there is the notable speech of Hamlet, when he says,

> Alexander died, Alexander was
> buried, Alexander returneth into dust: the
> dust is earth; of earth we make loam: and
> why of that loam, whereto he was converted,
> might they not stop a beer-barrel?
> Imperious Caesar, dead and turned to clay,
> Might stop a hole to keep the wind away.
> O, that that earth, which kept the world in awe,
> Should patch a wall to expel the winter's flaw!

Not only the material forming our bodies, but every piece of material around us possesses an antiquity so vast as to be almost incredible. What endless convolutions and vicissitudes, for example, has a common lump of earth passed through before it reached its present form? It has been part of continents which have long since vanished, and has borne the tread of races long since extinct. It has been on the top of mountains and at the bottom of oceans; it has often formed part of the molten fire underground, and, in spite of all this, it still remains, and will remain during endless ages yet to come.

All these wonders arise from the fact, brought to light by the patient labors of generations of scientific men, that matter is indestructible, that it can be neither generated nor destroyed by any means in our power. It may pass into a totally different series of forms, but at the end of a whole series of changes the same weight of matter remains as was there at the beginning. For example, when a candle burns away it disappears, and the matter forming it is apparently annihilated; yet this is not really so; for the candle merely burned to invisible gaseous forms of matter, which, when collected and weighed, are found to contain the same weight of carbon and hydrogen (the kinds of matter which make up the candle) as was originally in the candle itself. This latter fact, indeed, can be shown easily by means of a very simple experiment. A candle is fixed in a stoppered bottle which is then weighed. The candle is now lighted by making a platinum wire which encircles the wick, white hot by means of an electric current. The candle burns for a short time and then goes out. On reweighing the bottle when it is cold, no alteration in weight will be found to have occurred, although part of the candle has burned into invisible gas.

In the light of recent discoveries, however, it may be doubted whether matter is absolutely indestructible, but there is no doubt that ordinary matter, if decomposable at all, decomposes so slowly that a single pound of it will endure through millions of millions of centuries, a time longer than that required for the whole solar system to evolve.*

It is indeed hard to conceive that anyone in full possession of his senses can look into the heavens on a dark starry night and remain unmoved. The fact that he looks into a vast void extending upwards for ever and ever, strewn with innumerable myriads of suns and world-systems, must fill even the most brutalized mind with a feeling of awe and bewilderment. Yet the interspace between world and world is not truly empty in the popular sense; for it is filled with a wonderful medium, termed the *ether*, which fills all the depths of space, and bears through it to us, in the form of minute ripples or quiverings, the light of the distant stars. Matter moves through this vast sea of ether, apparently without resistance, much as a sieve moves through water, or a wind rushes through the trees; but what "matter" is, we do not know. All that we do know is that it is totally unlike anything which our crude senses conceive it to be, and is probably far more wonderful than anything we can even imagine.

We know that the solid objects about us are not really solid and impenetrable. They consist of countless millions of tiny particles, tiny atoms as chemists call them, in unceasing and swift motion. A single grain of lycopodium powder is made up of over a trillion of such atoms; earth, the paper on which I write, the very

* Sir Oliver Lodge, "Modern Views of Matter" (1903), p. 25.

air we breathe, consists of unimaginable millions of these tiny worlds, rushing and revolving rapidly as rifle bullets. Mendeleef likens the atoms to the heavenly bodies, the stars, sun, planets, satellites, and comets, and he considers that the building up of molecules from atoms, and of substances from molecules, resembles the building up of systems, such as the solar system, or of twin stars, from these individual bodies.

Even these atoms which build up ordinary matter are by no means solid masses. Far from it. Each atom is probably composed of a few thousands of tiny specks of negatively electrified particles, which fly about in astronomical orbits inside the atoms (much as a swarm of bees would fly about inside the dome of a great cathedral), forming a kind of cosmic system under their strong mutual forces, and occupying the otherwise empty region of space which we call the atom.

The porosity of matter as thus constituted is extreme, and this explains why it can move through the ether without apparent resistance. Matter hangs in space like a faint cloud, and is perhaps a mere misty modification of the wonderful space-filling fluid. Indeed, there is reason to believe that the one massive constituent of the universe is this invisible ether, and that our matter is a mere gauzy cob-web, a mist, or a milky-way floating in it. The reason why matter appeals to us so strongly and clearly is because our bodies are composed of it, and because our sense organs have been evolved to respond to its various motions.*

"Matter," says Francis Galton,† "is a microcosm of innumerable and, it may be, immaterial motes, and . . . the apparent vacancy of space is a plenum of ether that vibrates throughout like a solid." Nor must we forget that matter, as we know it, is but a collection of sensations generated in our brain by an exciting cause; the matter itself which lies behind and gives rise to these sensations remains forever unknowable, hidden behind the veil of changing phenomena. It is none the less real for all that, but still the fundamental fact remains that of the outer world we know nothing except our sensations. A landscape is nothing but a cluster of sensations. So also is a beautiful woman, a lovely flower, a child, a book. Between us and external reality stands an impenetrable intermediary, our nervous system. When we attempt to understand the inmost nature of the outer world, we stand before it as before utter darkness. Outside of ourselves there exists in Nature neither sound nor silence, brightness nor darkness, neither color, odor, space, force, nor anything that we know as sensation. The multitudinous sounds of Nature, the creaking of carts, the cries of animals, the wail of music, the awful roll of thunder are all produced by the excitement of our acoustic nerves, and exist only in our brains. As to the excitement itself, there is nothing to indicate that it is sonorous. It is in our brain that noise is produced; outside of it reigns eternal silence, or worse, since silence is the correlation of noise. Similarly, light is produced by the excitement of the optic nerve, and shines only in our brains; the ethereal vibrations themselves are not luminous. Outside us, then, is utter darkness; the flashing lights and colors of the outer world which incessantly assail us, the sudden glare of lightning, the gleam of gold and scarlet, the green of trees and fields, all the visible glories of the outer world, exist but in our brain. The same is true of all our other senses, and affects to an unknowable degree our conceptions of matter. We are utterly walled in by our nervous system.

We will now give a brief account of the views of the foremost modern thinkers upon the constitution of matter. A wonderful theory of Professor Osborne Reynolds ‡ assumes that the ultimate particles which make up matter are nothing but

* Sir Oliver Lodge, "The Structure of the Atom," *Journal of the Society of Chemical Industry* (1908), Vol. 27, p. 731.

† *The Times*, May 31, 1910.

‡ "The Sub-Mechanics of the Universe," Cambridge University Press, 1903.

empty cracks flitting to and fro like silent ghosts through the vast stagnant sea of ether. The ether is supposed to consist of an arrangement of indefinite extent of uniform spherical grains, generally so close that the grains cannot change their neighbors, although continually in relative motion with each other. The grains are extremely minute, the diameters being 5.534×10^{-18} centimeters (1 inch is 2.5 cms.). The millionth part of an inch could contain half a billion such particles packed side by side. The pressure in the medium is about 10,000 tons per square centimeter. In spaces in which there occur a smaller number of grains than is necessary to render the piling "normal," such local deficiencies are permanent. They can run through the medium without the medium moving with them, much as waves pass over water without a transfer of matter. They attract each other according to the laws of gravitation, and constitute the particles of matter. Hence, in contradistinction to our usual notions, matter consists of merely cracks or gaps of space; it is "emptiness," and not "fullness," as one would naturally suppose.

The theory gives a complete explanation of gravitation, the velocity of light, and numerous other physical phenomena.

According to another theory, matter is an electrical manifestation. It consists in aggregations of electrical particles, called by some authors, "electrons," by others, "corpuscles." The diameter of these particles has been calculated to be only 0.961×10^{-13} centimeters;* so that over 20,000,000 could be packed side by side in the millionth of an inch.

All the different elementary chemical atoms are made up of aggregations of many thousands of these minute bodies; these electrons or corpuscles, therefore, correspond to the long-sought primary matter or "protyle," out of which all the chemical elements are built up.

According to Larmor, the electrons are nothing but centers of strain, probably minute eddies, in the ether. These strain centers must not be thought of as part of the medium forever separated from the rest, for it is the strain alone which persists, the part of the ether which is affected by it constantly changing as the sub-atom is moved.

In Whetham's words,† "Matter is a persistent strain form flitting through a universal sea of ether, and ether, in its turn, is a close-packed conglomerate of minute grains in continual oscillation. . . . But what of the grains of which the ether is composed?

"Are they 'strong in solid singleness' like the one-time atom of Lucretius? Or have they parts within which opens a new field of complexity? Of what substance are they made?

"Has a new ether more subtle than the first to be invoked to explain their properties, and a third ether to explain the second? The mind refuses to rest content at any step of the process. An ultimate explanation of the simplest fact remains, apparently for ever, unattainable."

If matter is but a number of minute whirlpools in a universal sea of ether, surely by the slow diminution of their velocities in the course of ages these whirlpools must ultimately die out, again passing into the ether? The idea of the slow passage of matter into ether has been put forward by many recent writers, amongst whom may be mentioned Le Bon.‡ According to such a view, the material universe must be slowly disappearing. So that even the stately world-systems of space are smitten with a process of slow decay; even as the planets circle in silence around their central suns, they are rushing into oblivion, and ultimately must vanish, like clouds in a summer's sky, leaving no wrack behind them to show that they have been and gone. We have, however, no experimental proof of this view.

The most fundamental property of matter for dynamical science is *mass*.

* Arrhenius "Theories of Chemistry" (London), 1907, p. 91.

† "Recent Advances in Physical Science" (1904), pp. 282-294 (Murray).

‡ "The Evolution of Matter," by Dr. Gustave Le Bon (London), 1907. (Kegan Paul, Trench, Trübner & Co.)

The mass of the body used to be defined as a measure of the quantity of matter it contained. It is explained by the electronic theory of matter as an effect of electricity in motion. If this is so, it can be shown that the mass of a body must increase with its velocity, and, indeed, actual experiments by Kaufmann showed that this is the case. According to this idea, the mass of a body is not invariable, but rapidly increases as its speed approaches that of light (3×10^{-10} cms. per second, or 186,000 miles per second), and were it actually to attain this speed, its mass would be infinite. It follows, therefore, that the velocity of no material body can exceed that of light. But if the velocity is less than the tenth part of this, the difference in mass from that at very low velocities is insignificant—below 1 per cent. As a matter of fact (excluding certain Cathode and Beta rays), matter is never observed with such high velocities. Even when planets crash together in space and flash instantly into vast masses of glowing rushing gas heated to a temperature almost inconceivable to us, the flying masses of ejected matter never attain velocities approaching that of light. Thus the eruptions in the new star of Perseus, in 1901, the result of some tremendous cosmical collision, did not attain a velocity greater than 466 miles per second. The greatest observed velocity of the huge flames on the sun is 528 miles a second—a velocity exceeding that of a rifle bullet nearly a thousand times. Tremendous as these velocities seem, they are barely the four-hundredth part of the speed of light, so that the deviation from the law of constancy of mass must, even in these extreme cases, have been insignificant.

The amount of matter in the universe is so great as to defy all comprehension. Our earth alone is a huge globe nearly 8,000 miles in diameter, weighing nearly 5.5 times as much as an equal bulk of water. The sun exceeds the earth nearly 300,000 times as regards mass; and there exist at least 100,000,000 suns visible in a large telescope, some of which are larger, some smaller, than our own sun. In addition to these visible suns there is, perhaps, an even larger number of dark suns, bodies whose existence is only revealed to us when they come into collision with other bodies and produce the new stars which, from time to time, suddenly blaze in the sky.

Now, even the smallest grain of dust visible to the eye contains nearly a billion atoms of matter. How many atoms then, occur in the whole giant bulk of the earth? How many in the whole universe? If a grain of dust is a wonder heap, a structure infinite in its complexity, what shall we say about the universe?

The whole of this tremendous bulk of matter does not consist of the same stuff throughout. Chemists have shown that there exist some eighty or ninety distinct kinds of matter termed elements. Everything we see about us on the earth is built up of atoms of these different elements, and the spectroscope tells us that the same 80–90 elements also build up the world-systems of space.

A LENSLESS STEREOSCOPE

The lensless stereoscope is announced from Zurich, a device which will produce the effects without the familiar and customary apparatus. It is the product of Dr. W. R. Hess of the University of Zurich, and from the early reports he seems to have made practicable the principle involved when one interposes the finger between the eyes and a stereoscopic picture. Screens are so placed as to cause each eye to view only the picture belonging to it and the combination of them in the two eyes produces the stereoscopic effect. The application of the device, according to Dr. Hess, is particularly for the motion pictures in which the figures will have not only the familiar movements, but will be figures in actual relief. With the addition of color, there will be possible a veritable revolution in graphic presentation.

The Hoosac tunnel, which is four and three quarters miles long, is to be exceeded in length by the Roger Pass tunnel through the Rocky Mountains which will extend five miles and cost $10,000,000.

THE ORIGIN OF THE ROCKY MOUNTAINS*

STORY OF THE CREATION OF THIS GREAT MOUNTAIN SYSTEM AS DECIPHERED FROM THE DOCUMENTARY EVIDENCE OF THE STRATA THEMSELVES

BY S. J. SCHOFIELD

INTRODUCTION

THE elevated and mountainous tract which borders the western portion of North America is made up of a number of parallel mountain systems, which trend northwest and southeast and hence parallel in a general way the corresponding Pacific coast line. This tract, known as the North American Cordillera, has a width of four hundred miles in southern British Columbia.

In an endeavor to describe the origin of the Rocky Mountains it may be well to precede the discussion by a general analysis of the North American Cordillera in Canada. This has been admirably done by Professor R. A. Daly whose monumental work on the geology of these mountains has just been published. The basis for the classification of the Cordillera is the great topographic or geographic breaks which cut it up into distinct mountain systems. These geographic breaks are expressed in the form of longitudinal valleys which are remarkable features of the Cordillera and, as far as present knowledge goes, they coincide with the great structural breaks on which a genetic classification of mountains should be based.

On approaching the Cordillera from the east the first range of the Rocky Mountain system rises from the monotonous plains in a long, abrupt line of serrated peaks, flanked at the base by a low range of foothills. This system extends from Montana to the Arctic Ocean, in the form of an elongated chain composed of three major segments, arranged in echelon, in which each successive northern segment is, as it were, stepped to the west. Each segment is composed essentially of a remarkable system of parallel ridges, whose strike corresponds to the general trend of the main range. The average width of the Rocky Mountain system in southern British Columbia and Alberta is about sixty miles, while at the Liard River it apparently loses its regularity and importance, only to again assume the same character farther north. In British Columbia and Alberta many peaks exceed 10,000 feet, while the average elevation ranges between 8,000 and 9,000 feet.

On the west of the Rocky Mountain system occurs the Great Rocky Mountain trench, a continuous geographic break, recognized from Montana as far north as Alaska, crossing the international boundary line in the vicinity of Dawson. In the southern part of the Cordillera in Canada, the Purcell Range—an elliptical-shaped mass of rugged mountains, occurs west of the Rocky Mountain trench. Separating the Purcell system on the east, from the Selkirk Range on the west, is the Purcell trench in which occur Kootenay River and Kootenay Lake. West of the Selkirk Range and separated from it by the Selkirk valley, comes the Columbia system. The last three systems, the Purcell, Selkirk and Columbia, trend very close to north and south, and hence are terminated to the north by the Rocky Mountain system which, trending northwest-southeast, cuts them off. The Columbia Range gradually passes into the Interior Plateaus, characterized by low rounded hills and plateau-like upland stretches, having a mean elevation of 3,800 feet above sea level. This is succeeded to the west by the Coast Range which parallels the Pacific coast,

* Published by permission of the Geological Survey of Canada.

Rocky Mountains—Note the folding of the rocks

hence trending in a northwest-southeast direction. The descent into the Pacific is precipitous and many deep fiords mark its contact. The most westerly subdivision of the Cordillera is the Vancouver Range constituted by Vancouver Island and the Queen Charlotte Islands, recently described by J. D. Mackenzie in this magazine. The southern extension of this island festoon is the Olympic range of Oregon.

DISTRIBUTION OF ROCKS

For the purpose of description the Canadian Cordillera can be grouped into two basins of sedimentation: a Pacific basin extending from the Columbia system to the Pacific Ocean; and an Eastern basin covering the area from the Columbia system to and including part of the Great Plains. These basins geologically can be considered as units in a genetic sense.

The Columbia range consists in great part of ancient gneisses and schists, the oldest rocks in the Cordillera. These rocks formed at one time the old land mass which extended in a northwest-southeast direction from Central America to the Arctic Ocean. The greater part of this old land is buried under recent deposits or has been destroyed by the invasion of vast quantities of molten rock. The majority of these gneisses and schists are of sedimentary or waterlain origin and hence must have been derived from a still more ancient land now unknown and shrouded in mystery. To the east and west of this old land lay basins in which sediments derived from it by agents of degradation accumulated in vast quantities, for the most part, on an ocean floor.

The Eastern basin, or geosynclinal, which forms the subject of this article, includes the area now occupied by the Selkirk, Purcell and Rocky Mountain systems. The Selkirk and Purcell ranges, with a geological history similar to that of the Columbia range, consist in great part of bedded rocks of Pre-Cambrian age, intruded by masses of igneous rocks of the granite family. The Rocky Mountain system, the youngest member of the Cordillera, is composed almost entirely of bedded rocks ranging from early Palaeozoic to late Cretaceous, while the Great Plains are underlain at the surface by deposits of Cretaceous and of Tertiary age.

Deposits of the last geological epoch, the Pleistocene, or Glacial period, are scattered sporadically over the entire Cordillera.

BUILDING OF THE PURCELLS

If we could stand on the ancient land in the neighborhood of the Columbia range in Pre-Cambrian time, to the west could be seen a rolling and monotonous landscape of moderate relief, while to the east, as far as eye could see, a shallow sea in which was being deposited sand and mud derived from the gradual wearing away of the old land by atmospheric agencies and by running water. That this sea was shallow and remained shallow till Cambrian time is evidenced by the ripple marks, mud cracks, rill marks, and the casts of salt crystals now preserved in these hardened muds. At the dawn of the Cambrian period this ancient sea became greatly enlarged, and mingled its waters with those of the ocean. This mingling permitted the life which inhabited the ocean to invade the shallow continental sea, for it is in these deposits that we find for the first time definite fossil remains in the form of trilobites, brachiopods and marine worms. After this period the waters in the sea gradually deepened and marine invertebrate life abounded. This is shown by the presence of limestones containing abundant remains:—brachiopods, corals, and lamellibranchs in the Devonian and Carboniferous formations of the Rocky Mountains. During Jurassic time, represented by the deposition of marine, carbonaceous muds, the first forecasts of a great mountain building period were registered. During the latter part of the Jurassic, or early Cretaceous, the Purcell Mountains were built. They consist of immense folds of stratified rocks forming typically folded mountains strongly resembling the Juras of Europe and the Appalachians of the Eastern United States. The area

Rocky Mountains

affected by this folding is represented on our modern maps as constituting the land as far east as the Kootenay-Columbia valley or Rocky Mountain trench. It was in the neighborhood of this trench that the western shore line of the continental sea stood after the Jurassic Revolution. It had been shifted from the Columbia range as far east as the western part of what is now represented by the Rocky Mountains.

THE ORIGIN OF THE ROCKY MOUNTAIN SYSTEM

After the building of the Jurassic or early Cretaceous mountains, they were at once subject to destruction by the agencies of erosion. The results of this erosion can be seen in the Cretaceous strata of the Rocky Mountain system. From a study of these strata, which for the most part are composed of conglomerates (water-worn pebbles) and carbonaceous shales (hardened muds) with which are associated many seams of coal and impressions of fossil plants, it may be concluded that at certain times the Cretaceous sea was shallow enough to have a dense jungle growth thrive upon its vast deltas formed from the material derived from the destruction of the Jurassic mountain ranges (Purcell and Selkirk) to the west. Sedimentation continued throughout the Cretaceous until sufficient stress had accumulated locally in this part of the earth's crust for the generation of another great mountain system, the Rocky Mountain system proper. For the formation of this great thickness of Cretaceous strata, the Purcell and Selkirk Ranges were worn down to a low rolling landscape over which the meandering streams wandered sluggishly. This landscape, in technical language, is called a

peneplain, and since it was formed during Cretaceous time, a Cretaceous peneplain.

At the close of the Cretaceous or in early Tertiary, the Rocky Mountains were formed. The earth's crust in this region was raised first in a series of gigantic folds with their longer axes trending northwest-southeast or parallel to the Pacific coast. In the eastern part of the range blocks of the crust were pushed up and carried bodily over the surface for a distance, in the case of the most eastern blocks seen east of Banff, of eight miles. Thus the Rocky Mountain system is a series of parallel ridges with steep faces to the east and gentle slopes to the west, and, in a view from one of the higher peaks, strongly resembles the parallel waves of the sea as they approach the shore. This simile is made more striking by the presence of the snow and ice on the northeastern slopes of the peaks in strong contrast to the deep green coloration of the forest covered valleys. In the picture the snow and ice sparkling in the sun represents the foam on the waves and the green forest, the cool depths of the ocean.

SCULPTURING OF THE VALLEYS

The initiation of a mountain chain by the folding of any portion of the earth's crust marks the beginning of its destruction. Rain descending on this elevated portion collects into streams which rapidly, in a young mountain ridge, gnaws for itself a valley in the folded strata. This first ridge probably will form the axis of the range. The next ridge which rises will be the scene of a battle of giants seeking supremacy. The outgoing stream endeavors to maintain its course to the sea across the rising ridge which offers a barrier to its progress. From an examination of the transverse streams of the Rocky Mountains we see the victory invariably rested with the streams which now cut through the folds and fault blocks. These through-going valleys, making it possible for the transcontinental trains to reach the Pacific, have become the highways of commerce and travel. Such valleys are occupied by the Crowsnest Branch and the main lines of the Canadian Pacific and the Grand Trunk Pacific Railways.

These streams are termed antecedent streams since they kept their course in spite of the barriers raised (by the mountain uplift) against their progress. The longitudinal streams, on the other hand, occupy weak portions of the mountain area. In the Rocky Mountains they occur in areas of Cretaceous rocks which, being composed of soft shales, sandstones and conglomerates, are more easily eroded than the Devono-Carboniferous limestone on either side. These streams, called subsequent streams, since they are initiated subsequent to the mountain building, are tributary to the through-going or antecedent streams. The position of the valleys in the Rocky Mountains, in contrast to that of the Purcell Range to the west, depends entirely upon the structure of the mountains, that is, the drainage is impressed concordant with the folding and faulting of the underlying bedded rocks and hence the valleys belong to one cycle of erosion. In contrast to this, the drainage of Purcell Range is entirely independent of structure and its history can be referred to two cycles. In the first, during Cretaceous time, it was worn down to a peneplain, then uplifted concomitantly with the formation of the Rocky Mountain system. This uplift rejuvenated the streams, which again eroded out the present valleys which can be referred to the second or Tertiary cycle of erosion.

SCULPTURING OF THE ROCKY MOUNTAINS BY GLACIERS

The final moulding of the Rocky Mountains into their present form is due to the erosive action of ice. An examination of any area within these mountains would show that the heads of nearly all the streams terminate in a beautiful lake or tarn nestling in a rock basin. The basins are called cirques and owe their origin to the work of snow and ice. The configuration of this mountain tract previous to the Glacial period was naturally marked by inequalities in the upland stretches and in these inequalities snow would collect which, on the arrival of the

Rocky Mountains looking south—Note the steep eastern slopes and the gentle western slopes

glacial period, would not completely melt during the summer months and would continue to collect until, with the precipitation in the winter far exceeding evaporation in the summer, the collection of ice would slowly move down the slopes into the valleys. The inequalities which would be filled with snow would gradually enlarge by the movement of the water underneath the snow and even by the snow itself as it crept slowly down the slope. With increasing diameter these depressions would be occupied first by a permanent snowfield and finally by the névé of a glacier. Plucking action along the bergschrund would now rapidly push erosion headwards. This action is well described by D. W. Johnson * who descended 150 feet into a bergschrund in a glacier in the Sierra Nevada. "It was in all stages of displacement and dislodgement, some blocks having fallen to the bottom, others bridging the narrow chasm and others frozen in the névé. Clear ice had formed in the fissures of the cliff, it hung down in great stalactites, had accumulated in stalagmitic masses on the floor." Here he states that for a considerable part of the year there would be "a daily alternation of freezing and thawing. Thus a cliff would be rapidly undermined and carried back into the mountain slope, so that before long the glacier would nestle in the shelter of its own making. The ice grips like forceps any loose or projecting fragment in its rocky bed, wrenches it from its place and carries it away. . . . as the cirques receded, only a narrow neck would be left between them, which would ultimately be cut down into a gap or col. Thus a region

* D. W. Johnson, *Science*, new series, Vol. 9, 1899, p. 106.

of deep valleys, with precipitous sides and heads, of sharp ridges and of more or less isolated peaks, is substituted for a rather monotonous, if lofty, highland."

From the above description it can be seen that the detailed beauty of the Rocky Mountain system with its castellated crags, horns, cols, aretes, and cirques, is not due to the forms originating with the building of the mountain ranges: this merely places the foundation for the subsequent superstructure which is created in its main outlines by the erosion of running water, while the final decorations are furnished by the artistic touch of snow and moving ice.

Instrument House, Halemaumau, April, 1912, looking west. Photo., E. Moses

THE DIARY OF KILAUEA

An important contribution to scientific knowledge is that just published by the Society of Arts. The Institute has recognized the need of systematic observation of volcanoes and for the purpose has established in the Hawaiian Islands an observatory, where, with most recent methods and equipment, the facts that the crater has to offer are to be collected. The work owes its initiative to the interest and activity of Professor T. A. Jaggar, Jr., of the Geological Department, who is the director of the Hawaiian Volcano Observatory.

The report of the Hawaiian Volcano Observatory is a neat quarto of seventy-five pages, well illustrated, which gives the history of the institution and its work up to and including 1912.

In 1912 the observatory was put on a five-year foundation, and early in the year the present building was constructed. Dr. Jaggar was named head of the observatory and relieved of his duties in Boston for the purpose of making investigations at the volcano of Kilauea, where the station is located.

The Institute has the lease of a tract of three acres on the brink of the crater, with the option of renewal, and its station includes living rooms, administration offices and work rooms, while the Whitney Laboratory of Seismology is a basement room of concrete, floored on the solid ledge of basalt. The place of the instrument house is most striking, being on the very edge of the rim, where at times the clouds from the crater encompass it. During some of the experiments it has been necessary to establish a line of assistants who by calls from one to another directed the manipulation of the instruments.

Hawaiian Volcano Observatory, April, 1912, looking north. Photo., E. Moses

The story given in the report is largely a day by day account, and valuable for scientific purposes. The conduct of the fiery lakes in the bottom of the crater is chronicled, the oscillations of the lakes

Halemaumau, about January 4, 1912, looking west. Photo., Chock Chong

within their basins, the different kinds of action, the fountains, one of which, "old faithful" was playing at intervals of thirty seconds, sending fiery spray to one hundred feet in height, while the earthquake shocks of every little while are noted.

Experiments were made in gas-composition of the vapor clouds above the lakes, the flows of molten lava into fiery pools were described and the floating island. New cones on the floor of the great crater were a phenomenon of interest, the fall of the crater walls, the range of the fire with reference to surface, were features in an activity that knows no cessation.

Part of the work was that of Perret and Shepard, the former the well-known vulcanologist and the latter detailed for the work by the Carnegie Institution. In this series of observations, a cable was stretched across the lake and from it the thermometers were lowered into the lava to ascertain its temperature. It was a very difficult performance, and one after another of the instruments were lost, on account of the heat and acid condition of the vapors, which melted or corroded the wire ropes. One record was obtained, however, at 1800° Fahrenheit, and the moment after the wire ropes were melted and the instrument lost. It was the third pyrometer thus to be destroyed, but the observation is considered to be a good one of the temperature of Kilauea lava.

One of the striking matters presented by this volume is a bit of prophecy. Dr. Jaggar thinks that there is a rhythmic escape of lava, which has been fairly well verified by the records of past eruptions. Mauna Loa, which is the subject of this prediction, seems to have decreased the duration of its eruptive periods, which previous to 1868 were eleven and one-half years long, and since that date have been five years long. The time between these periods when the volcano has remained quiet has decreased from five and one-half years to four and three-quarters. Applying these figures to the last eruption, Dr. Jaggar is looking for renewed

Halemaumau, September 19, 1909, looking southwest, showing traveling fountains, spatter rampart, and flows. Note men in foreground. Photo., E. Moses

activity in this volcano in February, 1915. There is really no satisfactory information on which to predict the month, but from the usual conduct of the volcano, February seems the most probable. It will be of great interest to know whether this prediction, made in September, 1912, is fully realized.

THE STABILITY OF LIFEBOATS

RESULTS OF INVESTIGATIONS MADE TO DETERMINE THE EFFICIENCY OF SOME OF THE MORE COMMON TYPES OF LIFEBOATS IN GENERAL USE

BY H. A. EVERETT

The following presents the results of an investigation undertaken the past summer to determine the stability of several types of lifeboats in common use on ocean-going ships of these parts. The boats were all stock boats, new, and ready for immediate service.

In its essence, the work consisted of the customary calculations for the curves of statical stability after having made inclining experiments upon each boat to determine the location of the center of gravity. There were four boats and each was inclined in two conditions (1) light with but the apparatus and the two observers on board, and (2) loaded, with the number of persons which the Rules and Regulations of the United States Board of Supervising Inspectors permit. The work provided theses for two members of the graduating class of the Massachusetts Institute of Technology, A. H. Pitz and C. S. Hsin, and was under the immediate supervision of the author.

Four boats were used; the principal dimensions are given in this table, and the lines are given on Plates 1 and 2.

Those of figures 1, 2, 3, 4 were of the standard type of open boat provided with tanks as shown on Plate 2 and were of practically the same external form. Construction plans of the steel one are shown on Plate 2. Both conform to the U. S. rules with air-tank capacities of 51.8 and 76.4 for the wood and metallic boats, respectively.

Figures 5 and 5a show a boat of radically different form which falls within the class commonly called decked lifeboats, as the passengers are carried above a second water-tight skin or deck. It was built of metal (No. 14 B. W. G. galvanized iron) in accordance with the construction plans on Plate 2, and the lower space serves at all times as an hermetically sealed buoyant chamber.

On Plate 1 (lower) is shown a collapsible boat which consists essentially of a flat pontoon of wooden construction pointed at each end, and provided with wooden thwarts, rail and canvas bulwarks. These all fold down onto the upper deck or can quickly be raised and clamped into position when the boat is to be used. A con-

PRINCIPAL DIMENSIONS

Number	Type	Material	Length	Breadth	Depth	Capacity by U. S. Rules	*Weight, Light	Weight carried when tested	Corresponding Number of Persons	Load Displacement
1	Standard	Metal	28′	8′ 4″	3′ 7″	50 Persons	3584	7639	51	10559
2	Standard	Wood	28′	8′ 4″	3′ 7″	50 Persons	2740	7854	52	9784
3	Decked	Metal	28′	9′ 4″	2′ 7″	60 Persons	5392	9962	66	14462
4	Collapsible	Wood	29′ Top 28′ Bot.	9′ 0″	3′ 0″	54 Persons	† 3267 8840	2380	16	12720

* Incl. Exptl. App. and 2 Men.
† Before and after launching.

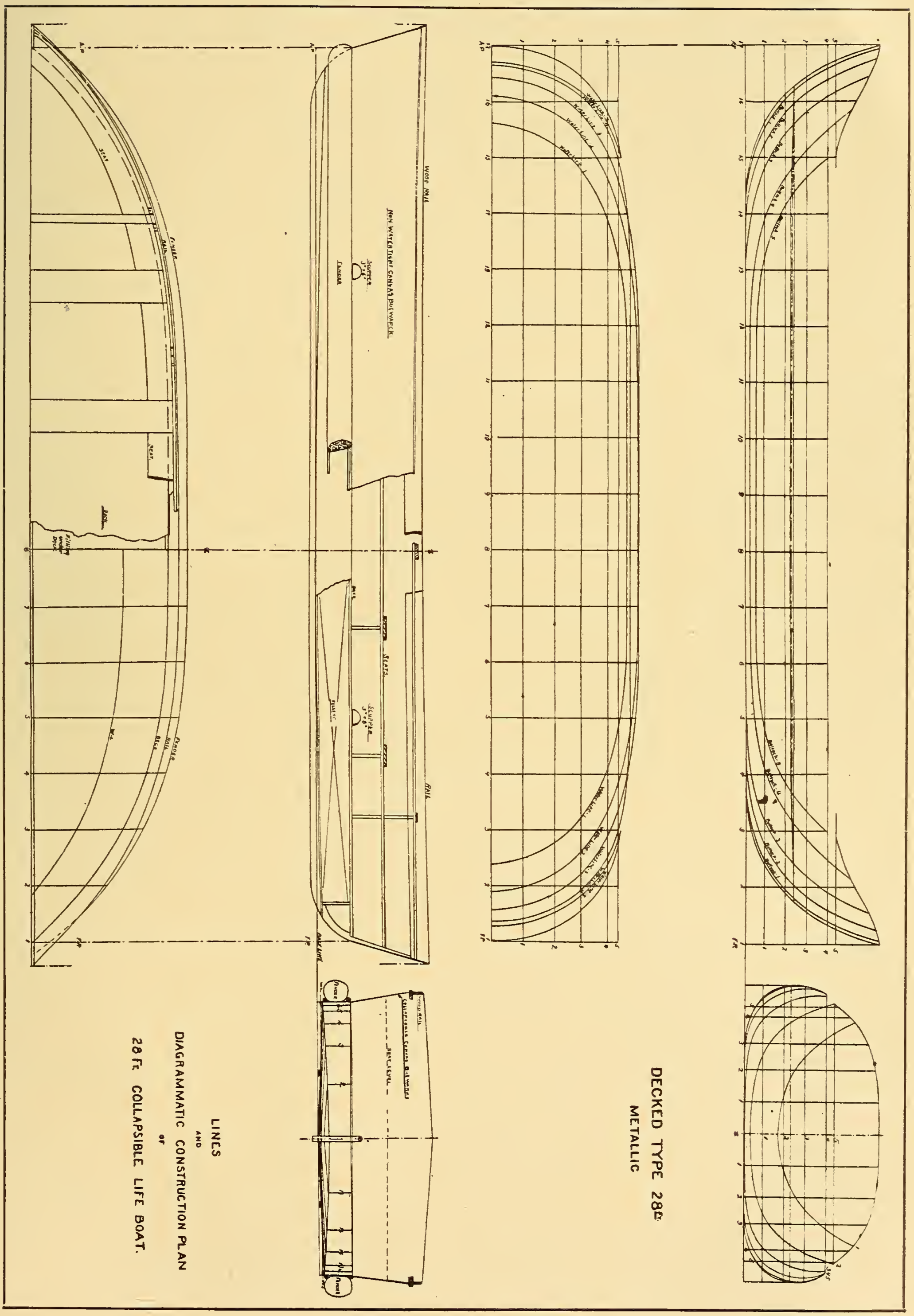

LINES
AND
DIAGRAMMATIC CONSTRUCTION PLAN
OF
28 FT. COLLAPSIBLE LIFE BOAT.
DECKED TYPE 28 FT.
METALLIC
NON WATERTIGHT CANVAS BULWARK.
SEATS.
FENDER
WOOD RAIL

Plate 1

TABLE OF CHARACTERISTICS OF FORM

Conditions	Met. Rad. B. M.	Met. Ht. G. M.	C. B. above base	C. G. above base	Mentacentre above base	Displacement. Lbs.	Draft above base	Type	Number
Light	5.55′	4.29	.41	1.67	5.96	3584#	.72	Standard—Metallic.	1
Loaded	3.58	1.39 / 2.04*	.86	3.05	4.44	10559	1.56		
Light	5.69	4.05	.35	1.99	6.04	2740	.56	Standard—Wooden.	2
Loaded	3.54	1.09 / 1.52†	.86	3.31	4.40	9784	1.44		
Light	11.31	9.21	.341	2.44	11.65	5392	.56	Decked—Metallic.	3
Loaded	5.67	3.10	.742	3.31	6.41	14462	1.31		
Light	6.43	3.14	.497	3.79	6.93	8840	.76	Collapsible—Wooden.	4
Loaded	5.23	.67	.614	5.17	5.84	12720	1.04		

* With load partly on bottom.
† This has since been done in the latest boats built by one of the large manufacturers.

struction plan in detail was not available for this type; but its general characteristics are shown by the figure on Plate 1. Compactness of stowage and suitability for nesting have been factors which have influenced appreciably the design of this type.

All boats were new, in the best of condition, and had been obtained direct from the makers.

In order to be of the most value, a basis for comparison must be used which involves either size or capacity. The former was chosen, and all boats were of the 28-foot size.

The inclining experiments were carried out using two plumb-bobs (one at each end) about 5 feet long. Pig lead was used for the inclining weights, and readings were taken with the lead on the center-line amidships, then to port, starboard and back to the center-line. The boats were in all cases in absolutely quiet water, and several readings were taken for each position with an agreement which was entirely satisfactory (seldom over one per cent).

The worst case as far as stability is concerned is when the boats are loaded to their full complement and that condition was simulated by loading the thwarts with sand bags (about 75 pounds each), so stowed that the center of gravity of each pair of sacks was at the proper height for a man sitting in that place. The height that this should be was determined by balancing a man fast to a plank in a sitting position and was found to be very close to 9 inches above the seat. Although two sacks averaged close to 150 pounds, the ballast was weighed each time it was put aboard in order to check the total weight. In most cases there were several persons in excess of the allowed load on board when investigating for the full load condition; but the resultant curves of stability, both statical and dynamical, have been corrected so they include only the number of persons that the inspection rules permit.

The table on this page gives the characteristics of form, centre of gravity, etc., of all types used:

Plate 3 gives the curves of statical stability (in terms of righting moment) for the boats in the fully loaded condition (allowable load) except in the case of the collapsible, and the table at the bottom of page 135 is derived therefrom:

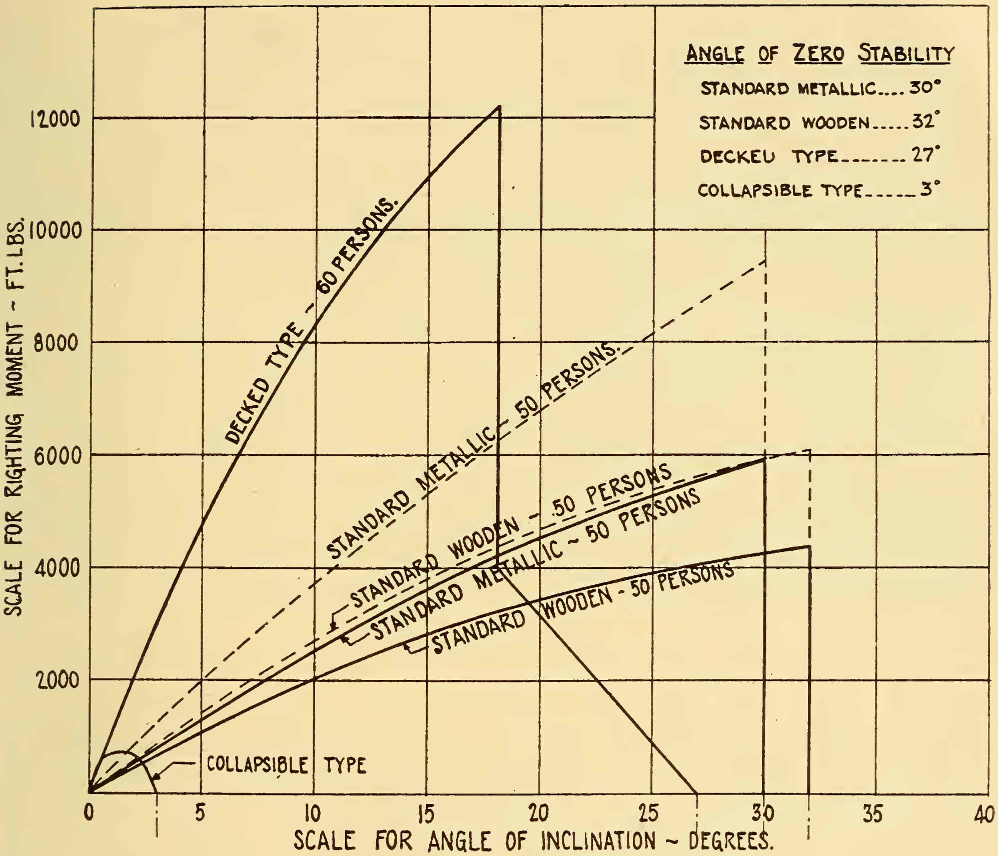


Plate 3

Angle of Inclination	Righting Moment in Foot-Pounds			
	Standard Metallic	Standard Wood	Decked Metallic	Collapsible Wood
5°	1300	1080	4780	Neg.
10°	2500	2030	8350	Neg.
15°	3620	2820	10980	Neg.
20°	4550	3440	3180	Neg.
25°	5300	3910	910	Neg.
30°	{ 5900 / 0* }	4280	Neg.	Neg.
Angle of Zero Stability	30°	32°	28°	3°

* Curve drops from 5900 to 0 at 30°.

Fig. 1. 28' x 8'4" x 3'7" Standard type wooden life boat, light condition

Fig. 2. 28' x 8'4" x 3'7" Standard type wooden life boat, loaded condition, 50 persons

The open boats, Figures 1, 2, 3, 4, have a continually increasing righting moment until they reach such an angle that the rail goes under (30 degrees for the metallic and 32 degrees for the wooden) when the boat founders. The curves are normal and quite what one would expect, though it is of interest to note the very appreciable increase in stability which is caused by the seating of a portion of the passengers (15 in the metallic and 16 in the wooden) on the bottom of the boat instead of on the thwarts and seats provided for them. It is noticeable also that the

wooden boat has less stability than the metallic, though of the same external form. This was caused partly by the center of gravity of the boat itself being somewhat higher and partly by the fact that the thwart and seats were about one inch higher above the keel than in the metallic boat. The construction plans show no reason why the thwarts and seats should not be lowered appreciably and it would seem desirable to have them as low as possible.

For example the wooden boat from the cross curves has an uncorrected righting arm when loaded with 50 people and inclined at 30 degrees, of 0.90 feet. The distance of the center of gravity above the assumed axis of inclination is 11 inches, or 0.92 feet.

The correction for the righting arm is then $0.92 \times \sin 30$ degrees $= 0.46$ feet, and the corrected righting arm is $0.90 - 0.46 = 0.44$ feet.

Now if the thwarts were lowered 6 inches, the resultant center of gravity would be lowered 0.35 feet, in which case the correction would be $0.57 \times \sin 30$ degrees $= .28$ feet, and the corrected righting arm is $0.90 - 0.28 = 0.62$ feet, which is an increase in statical stability of about 40 per cent.

Probably the curves of dynamical stability on Plate 4 give the most comprehensive comparison of the merits of the different types from the stability view-point as they give the *work done* in foot-tons to incline the boats to the various angles. These were derived by integrating the curves of righting moments, using one of the Institute's integraphs for the work. The following tables are derived from these curves.

TABLE OF DYNAMICAL STABILITY—LOAD CONDITION

Angle	Work done in Foot-tons to incline to Angle			
	Standard Metallic	Standard Wood	Decked Metallic	Collapsible Wood
5°	.024	.020	.105	....
10°	.100	.078	.390	....
15°	.230	.173	.785	....
20°	.395	.300	1.155	....
25°	.580	.443	1.230	....
30°	.800	.600	....	....

DYNAMICAL STABILITY—LIGHT CONDITION

	Metallic	Wooden	Lundin	Collapsible
5	1630	700	4200	5600
10	3000	1350	6600	6000
15	4120	1910	8180	3120
20	5120	2400	9140	610
30	6700	3000	9700	neg.
40	7700	3100	8050	neg.
50	8200	2800	5280	neg.
60	8400	2350	2350	neg.

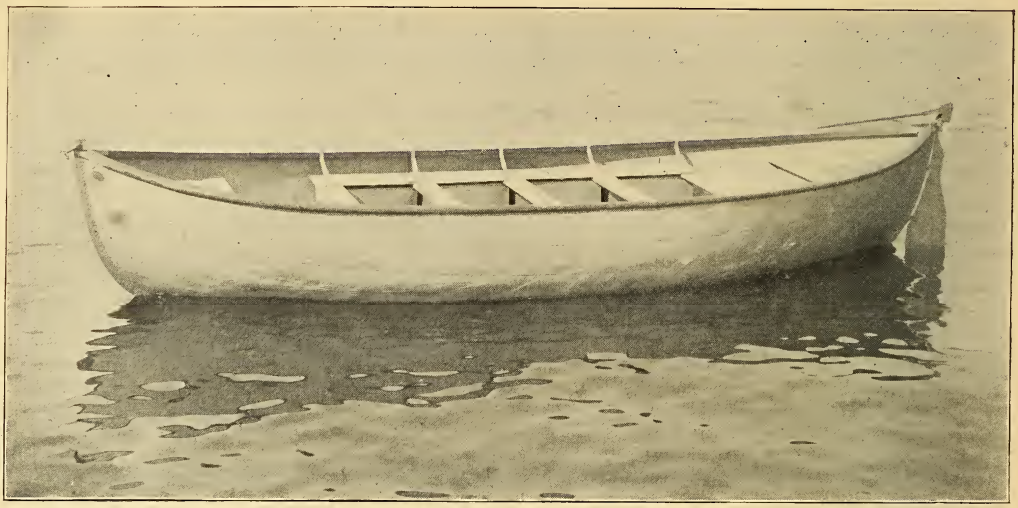


Fig. 3. 28′ x 8′4″ x 3′7″ Standard type life boat, light condition

Fig. 4. 28′ x 8′4″ x 3′7″ Standard type metallic life boat, loaded condition, 50 persons

Somewhat startling results were obtained with the collapsible boat. This was a new boat, obtained with the customary guarantee and was supposed to be in all respects ready for immediate service. It was of the dimensions given in the table and rated to carry 54 persons. When the inclining experiments in the light condition were made, the boat did not come to a position of equilibrium after the inclining weights were moved to one side, as the plumb-bobs showed a slow but continually increasing angle, the reason being that water was slowly leaking into the pontoon. The boat was hauled out and a few days later re-launched, hoping that it had swelled tight; but with the same result. A position of equilibrium was eventually reached after several hours in the inclined position and the center of gravity determined.

When it came to the loaded condition, the boat sank completely with 43 persons aboard, so that it was decided to accept for the load condition a less loading, one which would permit of the craft remaining

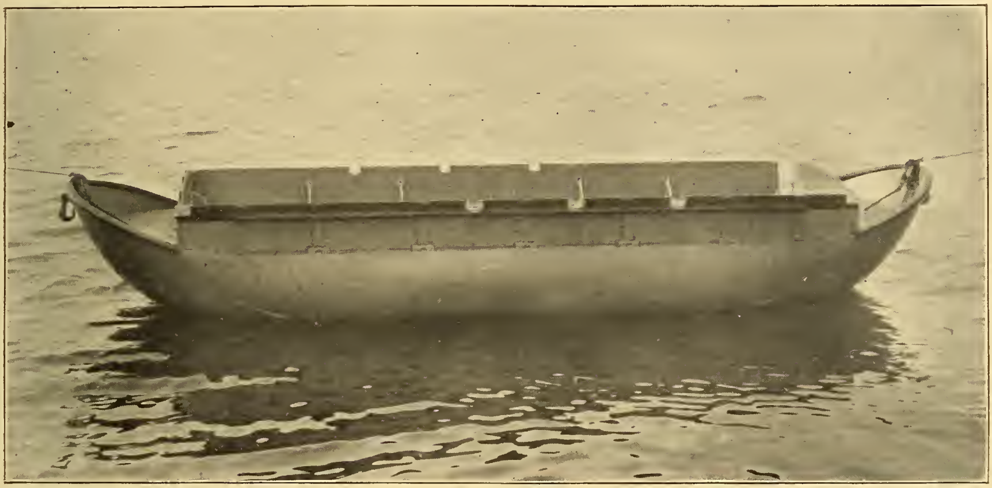


Fig. 5. 28′ x 9′4″ x 2′7″ Decked type life boat, light condition

Fig. 5a. 28′ x 9′4″ x 2′7″ Decked type life boat, loaded condition, 60 persons

afloat. Sixteen persons resulted in a freeboard of 1¼ inches to the top deck and this was the load used. The curve of righting moments when loaded with 16 persons, is shown on Plate 3 and it is interesting to note that the angle of vanishing stability is *three degrees.* The curve of dynamical stability is so small that it could not be shown on Plate. 4.

The failure of this boat to live up to a higher percentage of its requirements was undoubtedly due to the water leaking into the chamber between the decks and being gradually absorbed by the loose filling, buoyant material contained therein and placed there for the very purpose of providing sufficient buoyancy in case the covering of the pontoon is punctured.

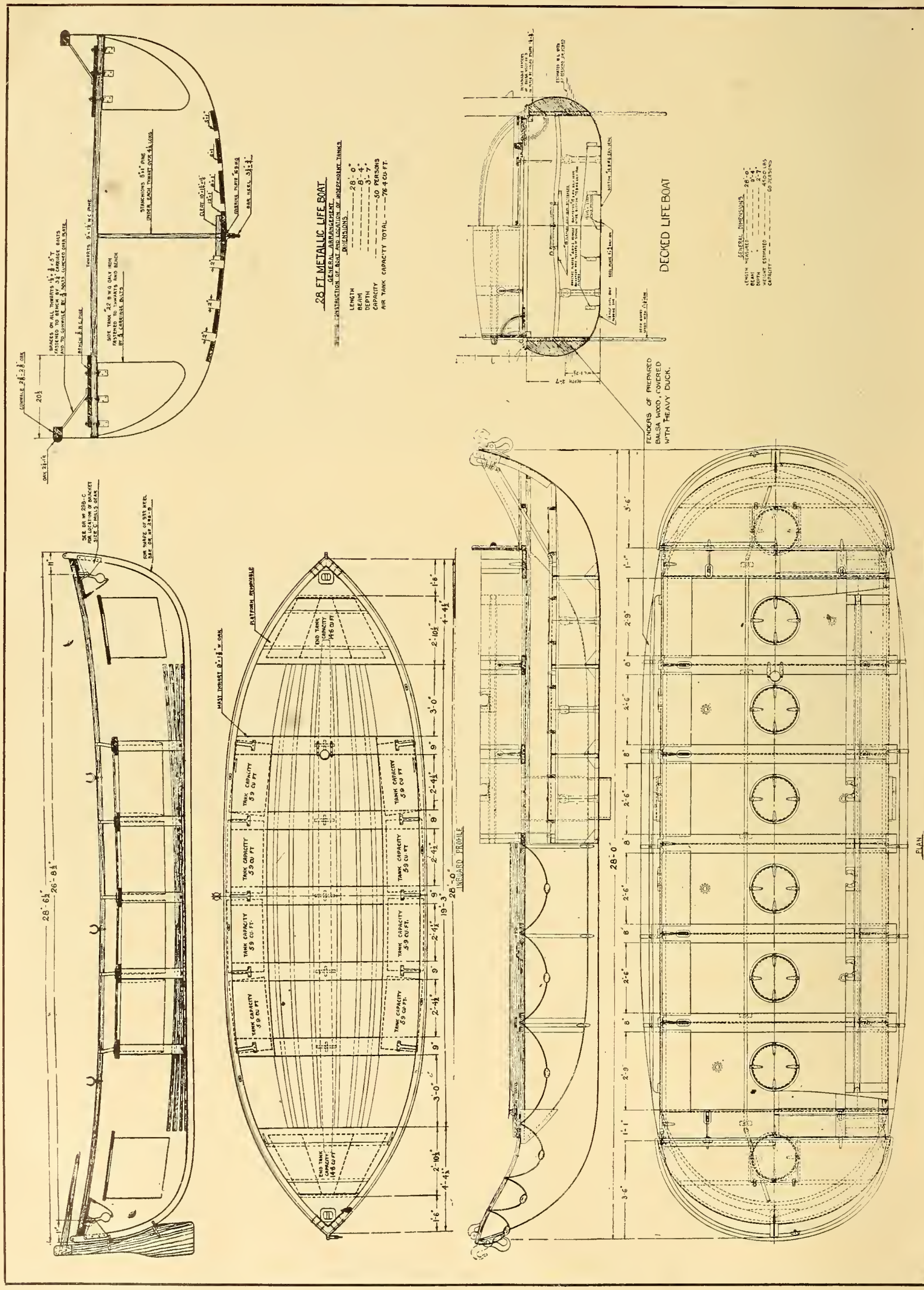

28 FT METALLIC LIFE BOAT
GENERAL ARRANGEMENT
DECKED LIFE BOAT
FENDERS OF PREPARED BALSA WOOD, COVERED WITH HEAVY DUCK.
INBOARD PROFILE
PLAN

Plate 2

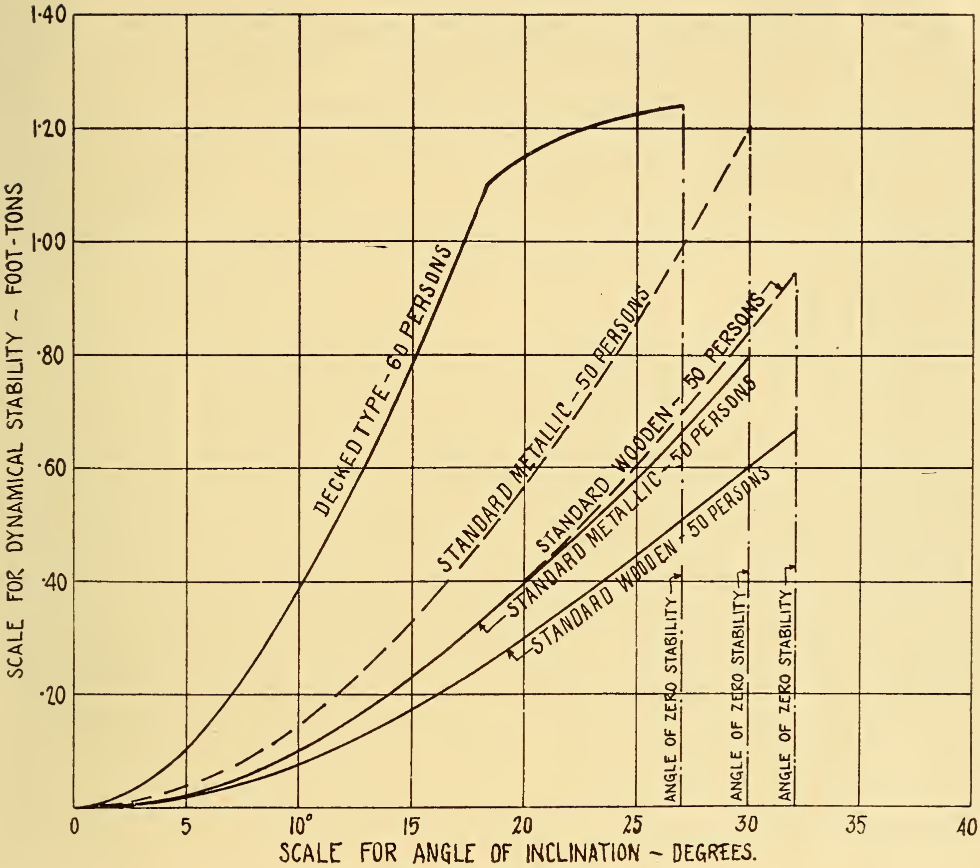


Plate 4

The essentially vicious feature from a construction point of view is that while water leaking in entirely eliminates the craft's stability and seriously impairs its buoyancy, the leakage is unknown and cannot be bailed out as in an open boat. Moreover, any wooden construction subjected to the ordinary weathering and wear encountered on the decks of ocean-going vessels will not and cannot be expected to remain water-tight. The bulwarks are not intended to be water-tight and the stability curve when light has all the characteristics of that of a raft, with its quick-rising curve of righting moments for very small angles and reaching zero stability at an angle vastly less than the standard type of boat. See Plate 3. The newer craft of this type are now built with metallic lower pontoons provided with internal water-tight subdivision which reduces the danger from free water inside but the characteristics are still essentially those of a raft more than of a boat.

LEGENDS OF THE BRIDGES

The breaking up of the isolation of Ceylon by the construction of a railway along the reefs, so that with one ferry the through journey may be made from the Continent, brings to mind the old Rama tale and, so comparing it with the story of the Giant's Causeway, one is struck by the wide distribution of the same

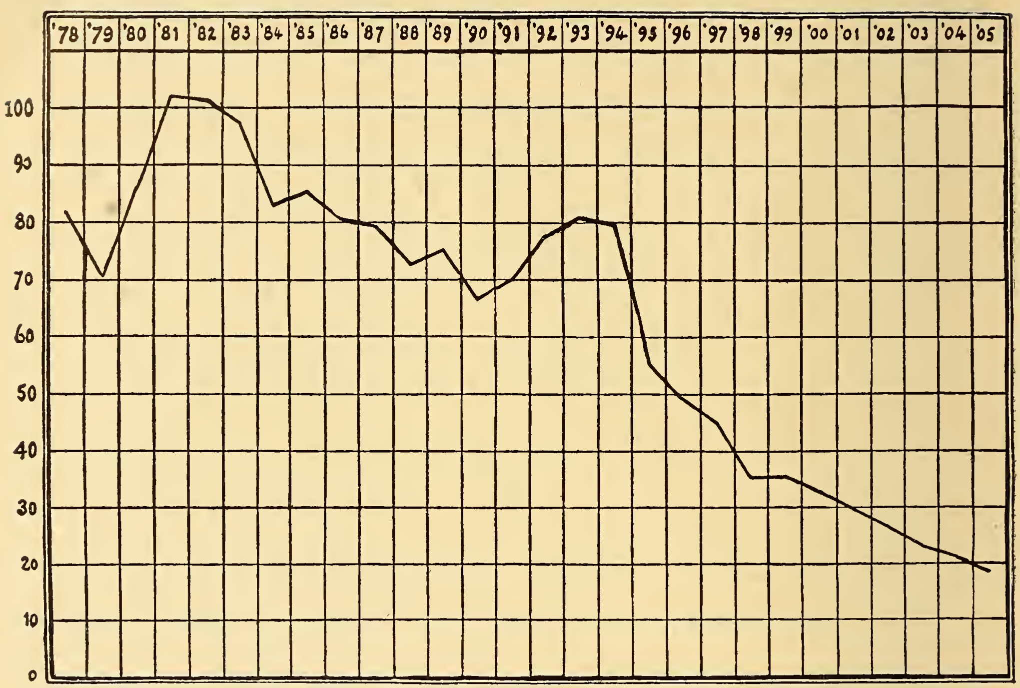
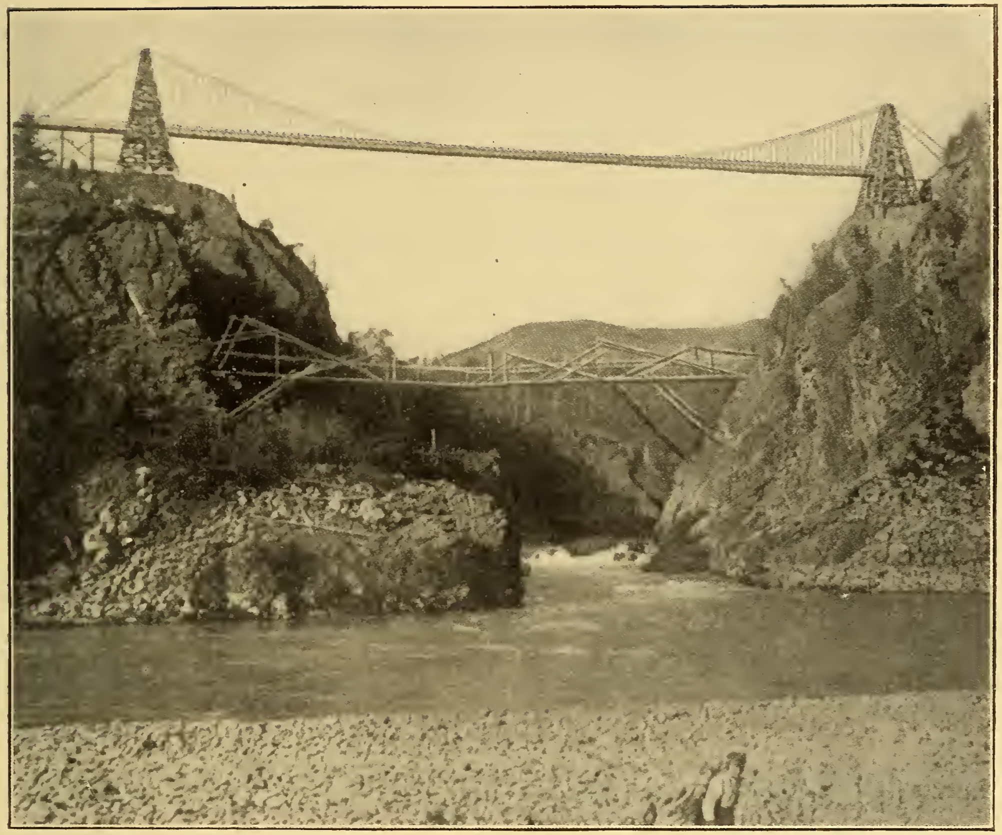


Chart showing the result of anti-toxin treatment in diphtheria. The curve represents the death rate from diphtheria per 100,000 of population in nineteen large cities of the world. Note the rapid fall in 1895, following at once the introduction of anti-toxin treatment in that year

legend. The two stories have naturally the imprint of their respective latitudes and peoples. In Ceylon, lying only ten degrees north of the equator, the bridge was for the rescue of a woman. Sita, the consort of Rama had been carried away by the demon king of Ceylon. Rama was aided by an army of monkeys and in five days (it ought to have been three or seven to be really consistent), the causeway was built. It followed the line of the reefs and Adams Bridge. Rama recovered his queen and in gratitude erected a temple on the island that has taken his name, Rameseram.

The northern bridge, whose great abutments of columnar basalt may be seen to this day on the Antrim County shore of Ireland and at the Isle of Staffa, was the work not of love, but of the rivalry of the northern Celts, whose weapons of old, the true ancestors of the shilaleh of Donnybrook, knew no brother. The bridge was built, the giants came over, though some legends have it that some waded, and sought the redoubtable Fin MaCool, who has a great variety of orthographies according to different authorities. Fin had tasted of the tree of knowledge by burning his thumb in cooking the king of the salmons, and whenever it was necessary to know anything some one reminded him to bite his thumb and thereupon the knowledge came to him. Fin was endowed with executive ability, that is to say, he made others do the things that were to be done. When the giants came over to finish him, he betook to the cradle and passed himself off as his own grandson, with his wife to do the tricky work and frighten the giants away. Fin was not a consistent Irish conception, and one would admire rather the faithful Rama in a holy quest, but the bridge connects more than Ceylon and Hindustan, it links the races of early man in a brotherhood little short of world-wide. J. R., Jr.



The Old and the New

The Engineering Record recently printed the picture of the two picturesque bridges shown on this page, which span the Bulkley River in northwestern Canada on the direct road to the Klondike. One is a modern suspension bridge, and the other is an old structure built by the Indians. This latter is the third of its kind that has been built here, the two earlier ones having been washed away by the river floods. It is an interesting example of Indian ingenuity, as no nails are employed in the structure, wooden pegs being used to fasten the members together.

It is stated that plants do not die suddenly through frost, but cell by cell, and death is retarded proportionally to the amount of undamaged tissue.

NEW MONT BLANC OBSERVATORY

An important visit of scientific men is planned to the summit of Mont Blanc, that of the building committee of the Society of Mont Blanc Observatories. For a good many years Janssen's observatory crowned the most lofty of the Alps, built for scientific purposes and in the hope that it would also serve for an Alpine cabin for mountain climbers. In the latter respect it was a failure, being very uncomfortable within.

The construction of the observatory followed what was probably the most remarkable mountain ascent on record, that of Janssen, the French physicist. He had the idea that from the top of the mountain, with the greater part of the

atmosphere below, it would be possible to make observations of the sun that would furnish much needed information. He expressed the intention of testing for himself the air at this level, notwithstanding his age and his inability to climb. For his trip he had constructed a narrow sled, with runners and with a long, overhead pole. Thirty guides were employed to propel the sled up and down the mountain following the usual route. In places only one runner touched, the sled being held in position by main strength by the guides. At one point it was declared impossible to drag the sled farther and Janssen alighted and tried to walk, but his strength was unequal to any effort and he could proceed at most but about one hundred feet. The ascent was accomplished; Janssen remained a day or two at the summit, and decided that science would be benefited by building the observatory.

The old building was much like the cabin of a ship. It was abandoned some time ago and has been swept away by the motion of the ice at the summit. In the meantime Vallot built a cabin on the Bosses, well toward the summit, a comfortable place which for a good many years has been doing splendid work in mountain meteorology.

On the death of Janssen, a few years ago, the present society of Mont Blanc Observatories was formed to care for the summit and the Bosses, and it is a committee of this society that has now raised the question of a new summit observatory. For the purpose some of its members will ascend during the present season and determine whether a new observatory is desirable. Mlle. Janssen, daughter of the scientist, is much interested and Vallot is one of the committee. In one respect the building of the new observatory will not be the tremendous task that the first one was. Since its erection the Swiss Alpine Club has placed cabins in all sorts of places nearly inaccessible: the Italians have put a hut high up on Monte Rosa and the technique of building at such heights has been pretty well established. Besides the guides are now quite accustomed to carrying up material and it is possible to secure it in portable form. J. R., Jr.

Science Conspectus

PUBLISHED BY THE SOCIETY OF ARTS OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY, BOSTON MASS. ::: SOLD ONLY BY SUBSCRIPTION

VOL. IV 1914 No. 1

The Aim of Science Conspectus

Not many years ago a man might say, "I have taken all science to be my province," but the field has so widened during recent times that today it would not be possible for one mind to compass even a single branch of science. Almost every day there are new developments in special lines of research, any one of which may lead to fundamental discoveries, but, although these matters would be of general interest if they could be understood, their significance is often obscure, even to scientific workers in not dissimilar lines, because of the rapid changes in the conception of the relations of matter, because of the intricacy of ever-expanding special nomenclature and because of the almost daily progress in methods of delicate manipulation.

It is the aim of SCIENCE CONSPECTUS to give a general survey of the field of science and its applications in such a way that every article will have some educational value for every reader. We shall strive to describe the most important current developments in the field of scientific activity in terms within the understanding of the intelligent lay reader, and in general we shall confine these descriptions to reasonable limits, often to the extent of brevity. We shall not attempt to preserve a balance in the amount of material presented between various branches of science. Most of the articles will be original material from authorities in their special lines of investigation. The publication staff will, however, make digests and summaries of important articles as they may appear in current publications, and we shall not hesitate to reprint any articles which may be of particular value to our readers. The matter in SCIENCE CONSPECTUS will not be printed simply because it is available, but will be carefully selected, and wherever possible will be amply illustrated.

Science Conspectus

PUBLISHED BY THE SOCIETY OF ARTS OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY, BOSTON MASS. ::: SOLD ONLY BY SUBSCRIPTION

VOL. IV 1914 No. 2

The Aim of Science Conspectus

Not many years ago a man might say, "I have taken all science to be my province," but the field has so widened during recent times that today it would not be possible for one mind to compass even a single branch of science. Almost every day there are new developments in special lines of research, any one of which may lead to fundamental discoveries, but, although these matters would be of general interest if they could be understood, their significance is often obscure, even to scientific workers in not dissimilar lines, because of the rapid changes in the conception of the relations of matter, because of the intricacy of ever-expanding special nomenclature and because of the almost daily progress in methods of delicate manipulation.

It is the aim of SCIENCE CONSPECTUS to give a general survey of the field of science and its applications in such a way that every article will have some educational value for every reader. We shall strive to describe the most important current developments in the field of scientific activity in terms within the understanding of the intelligent lay reader, and in general we shall confine these descriptions to reasonable limits, often to the extent of brevity. We shall not attempt to preserve a balance in the amount of material presented between various branches of science. Most of the articles will be original material from authorities in their special lines of investigation. The publication staff will, however, make digests and summaries of important articles as they may appear in current publications, and we shall not hesitate to reprint any articles which may be of particular value to our readers. The matter in SCIENCE CONSPECTUS will not be printed simply because it is available, but will be carefully selected, and wherever possible will be amply illustrated.

Science Conspectus

PUBLISHED BY THE SOCIETY OF ARTS OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY, BOSTON MASS. ::: SOLD ONLY BY SUBSCRIPTION

VOL. IV 1914 No. 3

The Aim of Science Conspectus

Not many years ago a man might say, " I have taken all science to be my province," but the field has so widened during recent times that today it would not be possible for one mind to compass even a single branch of science. Almost every day there are new developments in special lines of research, any one of which may lead to fundamental discoveries, but, although these matters would be of general interest if they could be understood, their significance is often obscure, even to scientific workers in not dissimilar lines, because of the rapid changes in the conception of the relations of matter, because of the intricacy of ever-expanding special nomenclature and because of the almost daily progress in methods of delicate manipulation.

It is the aim of SCIENCE CONSPECTUS to give a general survey of the field of science and its applications in such a way that every article will have some educational value for every reader. We shall strive to describe the most important current developments in the field of scientific activity in terms within the understanding of the intelligent lay reader, and in general we shall confine these descriptions to reasonable limits, often to the extent of brevity. We shall not attempt to preserve a balance in the amount of material presented between various branches of science. Most of the articles will be original material from authorities in their special lines of investigation. The publication staff will, however, make digests and summaries of important articles as they may appear in current publications, and we shall not hesitate to reprint any articles which may be of particular value to our readers. The matter in SCIENCE CONSPECTUS will not be printed simply because it is available, but will be carefully selected, and wherever possible will be amply illustrated.

Science Conspectus

PUBLISHED BY THE SOCIETY OF ARTS OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY, BOSTON MASS. ::: SOLD ONLY BY SUBSCRIPTION

VOL. IV 1914 No. 4

The Aim of Science Conspectus

Not many years ago a man might say, "I have taken all science to be my province," but the field has so widened during recent times that today it would not be possible for one mind to compass even a single branch of science. Almost every day there are new developments in special lines of research, any one of which may lead to fundamental discoveries, but, although these matters would be of general interest if they could be understood, their significance is often obscure, even to scientific workers in not dissimilar lines, because of the rapid changes in the conception of the relations of matter, because of the intricacy of ever-expanding special nomenclature and because of the almost daily progress in methods of delicate manipulation.

It is the aim of SCIENCE CONSPECTUS to give a general survey of the field of science and its applications in such a way that every article will have some educational value for every reader. We shall strive to describe the most important current developments in the field of scientific activity in terms within the understanding of the intelligent lay reader, and in general we shall confine these descriptions to reasonable limits, often to the extent of brevity. We shall not attempt to preserve a balance in the amount of material presented between various branches of science. Most of the articles will be original material from authorities in their special lines of investigation. The publication staff will, however, make digests and summaries of important articles as they may appear in current publications, and we shall not hesitate to reprint any articles which may be of particular value to our readers. The matter in SCIENCE CONSPECTUS will not be printed simply because it is available, but will be carefully selected, and wherever possible will be amply illustrated.

Science Conspectus

PUBLISHED BY THE SOCIETY OF ARTS OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY, BOSTON MASS. ::: SOLD ONLY BY SUBSCRIPTION

VOL. IV 1914 No. 5

The Aim of Science Conspectus

Not many years ago a man might say, " I have taken all science to be my province," but the field has so widened during recent times that today it would not be possible for one mind to compass even a single branch of science. Almost every day there are new developments in special lines of research, any one of which may lead to fundamental discoveries, but, although these matters would be of general interest if they could be understood, their significance is often obscure, even to scientific workers in not dissimilar lines, because of the rapid changes in the conception of the relations of matter, because of the intricacy of ever-expanding special nomenclature and because of the almost daily progress in methods of delicate manipulation.

It is the aim of SCIENCE CONSPECTUS to give a general survey of the field of science and its applications in such a way that every article will have some educational value for every reader. We shall strive to describe the most important current developments in the field of scientific activity in terms within the understanding of the intelligent lay reader, and in general we shall confine these descriptions to reasonable limits, often to the extent of brevity. We shall not attempt to preserve a balance in the amount of material presented between various branches of science. Most of the articles will be original material from authorities in their special lines of investigation. The publication staff will, however, make digests and summaries of important articles as they may appear in current publications, and we shall not hesitate to reprint any articles which may be of particular value to our readers. The matter in SCIENCE CONSPECTUS will not be printed simply because it is available, but will be carefully selected, and wherever possible will be amply illustrated.